THE MITOGENETIC RADIATION OF THE HEART MUSCLE OF ANIMALS

A. A. Gurvich and V. F. Eremeev

Laboratory of Mitogenesis (Head, A. A. Gurvich), Institute of Normal Pathological Physiology (Director, Active Member of the Academy of Medical Sciences of the USSR Professor V. V. Parin), Academy of Medical Sciences of the USSR, Moscow
(Presented by Active Member of the Academy of Medical Sciences of the USSR V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 61, No. 6, pp. 56-58, June, 1966
Original article submitted June 2, 1964

The results obtained by the study of the mitogenetic radiation of skeletal muscles at rest in vivo have shown that the molecular substrate of the sarcoplasm is characterized by the continuous formation of extremely labile molecular units—"constellations," supplying energy for metabolism. Their spatial arrangement largely depends on the action of the nervous centers. In other words, rest must be regarded as a continuously regulated state, playing an active part in the formation of reactions to stimuli [1-5].

The objects of the present investigation was to study the structural and energetic state of the sarcoplasm of heart muscle.

Besides the automatism characteristic of the conducting system of the heart, which must be connected in some way with the organization of its molcular substrate, a factor of no less interest is the character of the substrate of the main muscle syncytium, itself changing in accordance with these changes, and thus creating conditions for the corresponding reactions of the contractile apparatus.

EXPERIMENTAL METHOD

The experiments were carried out on frogs and rabbits. In frogs the radiation was recorded from the whole surface of the ventricle of the heart, and in the rabbits from a localized area of the surface (1.0-1.5 cm^2) of the apex of the left ventricle. Some experiments were carried out without anesthesia, including the preliminary operation of thoracotomy (in the rabbits, in addition, the making of an incision into the trachea for artificial respiration).

For spectral analysis of the radiation, the frog was placed vertically in front of the collimator of the spectrograph and the heart was centered opposite the entrance slit. The radiation from the heart of the rabbit bound horizontally to a flame was reflected from an aluminum mirror situated at an angle of 45°, and thus directed into the entrance slit of the spectrograph.

A specially prepared yeast culture was used as detector of the radiation. The method of working with this culture has often been described [1-3].

EXPERIMENTAL RESULTS

Two series of experiments were carried out. In series I the intensity of the radiation from the heart of the frog and rabbit was studied in states as close as possible to normal and during general anesthesia. In frogs, parallel experiments were carried out in which the exposed cerebral hemispheres were cooled with physiological saline at a temperature of 2-3°. In the experiments of series II, a spectral analysis was made of the irradiation from the heart of both groups of animals, both in a normal state and under anesthesia.

The evaluation of the intensity of the radiation was based on a comparison of threshold exposures (taking into account the emitting surfaces). The shorter the exposure required, the greater the intensity of the radiation [1, 2].

Determination of Threshold Exposures of Radiation from the Frog's Heart*

Exposure (in sec)	Without stimulation	During anesthesia	During cooling of cerebral hemispheres
10	8	50	22
15	4	45	34
20	3	80	26
30	0	—	—
45	30	—	—
60	16†	—	—
90	—11	—	—

* The results are shown as the percentage increase in budding of yeast cultures. Mean data of 4-5 experiments are shown.

†The decrease in the positive mitogenetic effects with an increase in exposure (often cornered by the onset of negative effects) is well known from previous investigations.

It was found that the radiation from the rabbit's heart was approximately three times more intensive than the radiation from the frog's heart.

In the rabbits anesthesia (injection of 3-4 ml of 20% urethane solution into the auricular vein) did not change the intensity of the radiation from the heart. In the frogs, on the other hand, reversible ether anesthesia caused a considerable increase in the intensity of the radiation.

The numerical results, including those obtained during cooling of the cerebral hemispheres of the frog, clearly revealed a considerable shortening of the threshold exposures during exposure to both types of factor (see table).

The fact that the reaction was consistent, i.e., an increase in the intensity of the radiation during anesthesia and during cooling of the hemispheres, is understandable because in both cases these factors inhibited the activity of the nervous centers.

Some interesting results were obtained by spectral analysis, showing that the spectra of the radiation in the animals of both groups in normal conditions were similar as regards the width of the bands on the spectra of the resting skeletal muscles. In the heart of the warm-blooded animals the width of the bands was still more marked (Fig. 1).

The spectra were characterized by a small number of bands and by their grouping into a comparatively small range of frequencies.

It was previously shown that the wide-band character of the spectra must be regarded as an indication of the state of orderliness of the molecular substrate, i.e., an indication of the presence of common energy levels between the elements (molecules, molecular complexes) of the substrate.

A sharp change in the spectra was observed during anesthesia—the wide bands were replaced by narrower (Fig. 2). The border between the active region in the frogs was very slightly widened. For the rabbits, the scatter of the narrow bands throughout the range of spectral frequencies was characteristic. This sharp change in the spectra during anesthesia stresses that the state of the substrate of the heart is dependent on central factors and it suggests that the unbalanced molecular orderliness of the cardiac syncytium, specific for the waking state, is largely maintained by a continuous influence from these centers.

The starting point of this discussion is the idea of chain-like energy processes continuously generated in the nervous centers, spreading along the nervous pathways, and producing a corresponding adaptation of the molecular substrate of the sarcoplasm of the heart. With a considerable depression of the activity of these centers during anesthesia, and a weakening, or perhaps a qualitative change in the chain processes on account of this, the orderly molecular state of the sarcoplasm becomes less pronounced.

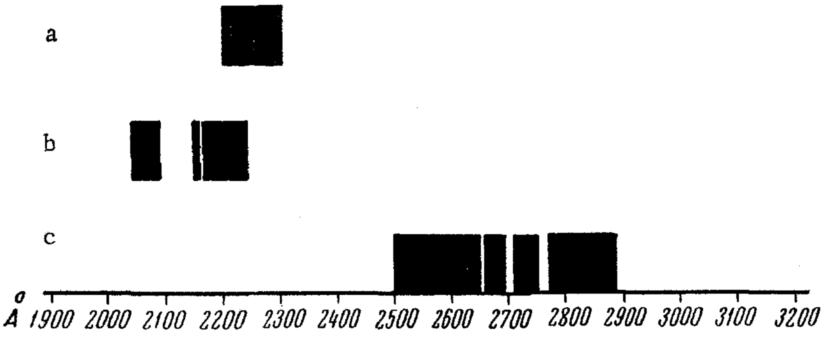

Fig. 1. Spectra of mitogenetic radiation of muscle systems. a) Spectrum of gastrocnemius muscle (of the frog and rabbit) at rest; b) spectrum of spontaneous radiation of the frog's heart; c) spectrum of the spontaneous radiation of the rabbit's heart.

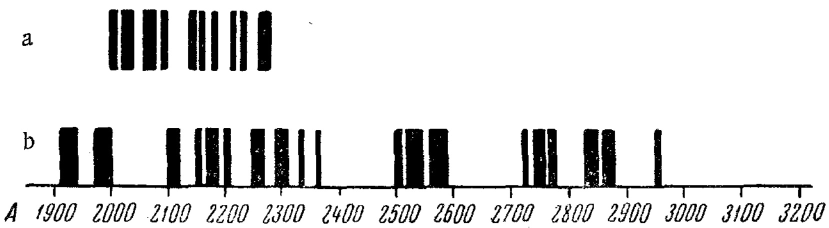

Fig. 2. Spectra of mitogenetic radiation of the heart during anesthesia. a) frog (during general ether anesthesia); b) rabbit (during general urethane anesthesia).

The results suggest that in the frog the unbalanced state of the substrate is less dynamic. It is shown mainly by spatial deformations of the large protein (peptide) complexes. During anesthesia the deformation of the complexes is diminished with the possible liberation of functional side groups, the radiation of which is characterized by narrow bands on the spectrum.

Concerning the sarcoplasm of the heart muscle of the rabbit it may be supposed that, in contrast, it possesses a more dynamic type of unbalanced state—with the predominance of mutually oriented molecules or small molecular complexes ("unbalanced molecular constellations"), whose ability to emit radiation is higher than that of macromolecular compounds.

Evidently both types of state of the molecular substrate, determined above all by the distribution of excited molecules in accordance with definite spatial principles, must facilitate the spread of locally arising deviations. In these circumstances the variety of spreading steric processes may be very great.

The results described and the conclusions deduced from them thus associate the concept of reactivity of the heart muscle with certain ideas concerning the state of its molecular substrate and they emphasize the continuous regulation of the substrate by the nervous centers.

LITERATURE CITED

1. A. G. Gurvich and L. D. Gurvich, Mitogenetic Radiation [in Russian], Moscow (1945).
2. A. G. Gurvich and L. D. Gurvich, Introduction of the Theory of Mitogenesis [in Russian], Moscow (1948).
3. A. G. Gurwitsch and L. D. Gurwitsch, Die mitogenetische Strahlung, Jena, Fischer Verlag (1959).
4. A. A. Gurvich, Byull. éksper. biol., No. 10, 82 (1960).
5. A. A. Gurvich, V. F. Eremeev, and M. A. Lipkind, Byull. éksper. biol., No. 4, 57 (1961).