MITOGENETIC RADIATION OF THE MYOCARDIUM AFTER PARTIAL DEAFFERENTATION

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The results of the study of the mitogenetic radiation of the heart muscle of frogs and rabbits in experiments in vivo show that the molecular substratum of the sarcoplasm of the cardiac syncytium of the physiologically normal animal must be regarded as an extremely labile, unbalanced regular system. The character of the regular arrangement of the molecules in these circumstances is largely dependent on direct influences from the neural centers [3, 4]. Probably, therefore, a disturbance of the normal innervation of the heart must give rise to considerable and prolonged changes in the state of the molecular substratum, which can be studied in chronic experiments by the method of spectral analysis of the radiation. The concept of the neurotrophic provision of the cardiac muscle in these circumstances could be expressed at the level of molecular processes.

In the present investigation a study was made of the mitogenetic radiation of the myocardium after partial removal of its afferent nerve supply. The role of that part of the afferent innervation of the heart supplied by the dorsal roots of the spinal cord was studied.

EXPERIMENTAL METHOD

The spinal ganglia were extirpated in cats at the level C_6-D_7 in two stages or at the level D_1-D_5 in one stage. The spectrometric experiments were carried out at different times after the operation. As a first step, after a short period of ether anesthesia and with repeated intravenous injections of urethane solution the thorax was opened (with artificial respiration) and the ventricles were carefully drawn towards the opening so that the apex of the left ventricle, on which an area of the surface measuring 1.5-2 cm^2 was demarcated, was accessible to the experimenter. The frame to which the animal was secured was placed just below the entrance slit of the spectrograph, so that the radiation of the heart reflected from an aluminum mirror situated above the heart and inclined at an angle of 45° was directed on to the slit. The surface of the heart was constantly moistened with warm physiological saline. The radiation detector was a yeast culture. The method of working with it was described earlier [1, 2].

EXPERIMENTAL RESULTS

The most convenient method of immobilizing the cats – general anesthesia (in these experiments, with urethane) – complicates the analysis of the results, as previous investigations have shown, for anesthesia modifies the state of the molecular substratum [3].

However, satisfactorily consistent results may be obtained by comparing the results obtained when urethane was used with those obtained with tricuran (gallamine), known to differ sharply from the general anesthetics in the mechanism of its action.

The results obtained may be subdivided into three groups: results characterizing the spectrum of the radiation of the myocardium of a cat immobilized with tricuran (two intravenous injections of the drug in a dose of 8 mg in the course of 45-60 min); results characterizing the spectrum of the cat's heart muscle after administration of urethane (3-4 intravenous injections of 2-3 ml of a 25% solution of urethane) over a period of 45-60 min; and results characterizing the spectra of the heart muscle at various times after partial deafferentation: 1 week, 2 months, and 1 year (also after injection of urethane).

Mitogenesis Room, Laboratory of Nervous Trophism, Institute of Normal and Pathological Physiology of the Academy of Medical Sciences of the USSR (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. 62, No. 7, pp. 55-59, July, 1966. Original article submitted June 2, 1964.

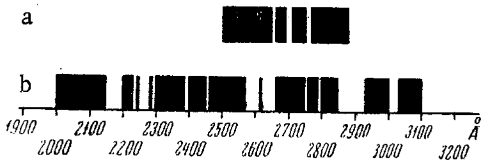

Fig. 1. Spectra of mitogenetic radiation of heart muscle in vivo. a) Spectrum of spontaneous radiation of a rabbit's heart; b) spectrum of radiation of a cat's heart after administration of tricuran.

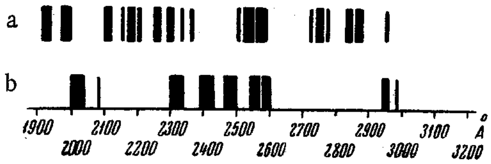

Fig. 2. Spectrum of radiation of a rabbit's (a) and a cat's (b) heart during urethane anesthesia.

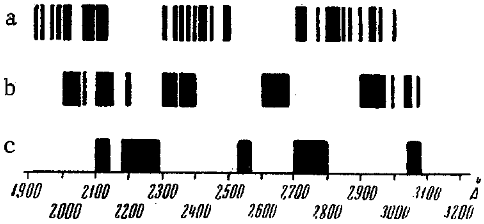

Fig. 3. Spectra of radiation of a cat's heart at different times after deafferentation under urethane anesthesia. a) 1 week; b) 2 months; c) 1 year after deafferentation.

A detailed study of the spectrum of the heart during the action of tricuran was made in two cats. A characteristic feature was the clear predominance of wide bands (50-150 A), distributed throughout the range of the spectrum. By the width of its bands the tricuran spectrum of radiation from the cat's heart was similar to the spectrum of the heart muscle of the unanesthetized rabbit (Fig. 1). This common feature is important, because it makes it possible to suggest with a higher degree of probability that the emission spectrum of the heart of a cat untreated in any way must also be of the wide-banded type.

Urethane anesthesia of the cat led to changes in the spectrum of the heart muscle: both the number and width of the bands were reduced, and the commonest bands in the spectrum were 30-40 A wide. In other words, the spectral changes observed in the cat's heart concerned especially the width of the bands were analogous to those caused by urethane in the emission spectrum of the rabbit's heart (fig. 2).

The study of the emission spectra of the cat's heart after deafferentation, also conducted under urethane anesthesia, gave the following results.

One week after deafferentation (experiments on two animals) a further increase was observed in the number of bands, mainly on account of the appearance of narrower bands. Two months after the operation changes of the opposite nature began to be observed in the character of the spectrum. The number of bands fell by comparison with the spectrum characteristic of 1 week after deafferentation. At the same time, the spectrum after 2 months typically showed the appearance of wider bands (the spectra of three animals were analyzed). The spectrum of the heart muscle of the cat 1 year after deafferentation clearly showed a further widening of the bands and a decrease in their number (the spectra of two cats were analyzed) (Fig. 3).

To analyze the results, the starting point was the general idea of the unbalanced, regular state of the molecular substratum of the sarcoplasm, an idea based on the description of the results obtained with skeletal muscle and the heart muscle of the frog and rabbit [3].

A regular molecular state means that the substratum may be regarded as an aggregate of systems with common energy levels [1-3]. The wider the bands of the spectrum, the closer the energy states of the elements (molecules) of the substratum, i.e., the more gradual the transitions between their energy states.

It seems very probable [3] that the sarcoplasm of the muscular syncytium of the heart in warm-blooded animals is characterized by a high degree of dynamism of the unbalanced, regular state, i.e., by continuity of disturbances (connected with emission) and of resotrations of temporary labile molecular ensembles or molecular "constellations."

Restoration of molecular regularity takes place on account of the energy of metabolism [1, 2], but the character of the regularity, i.e., the "molecular architecture" of the sarcoplasm, is largely dependent on the continuous influence of the nervous centers. This is shown by the sharp changes in the emission spectrum of the heart which arise as transient phenomena during anesthesia and as longer phenomena after denervation of the heart.

It is evident that the unbalanced molecular regularity, i.e., the spatial proximity of the excited molecules, and their more or less definite orientation relative to one another must be very important for the spread of chain processes. The selective spread of certain types of processes or, in other words, a definite degree of regulation of the chemism, appears to be perfectly possible in these circumstances.

The general physiological meaning of the changes observed in the spectra may thus be formulated as follows.

The molecular substratum of the sarcoplasm of the heart muscle, whose interaction with the nervous centers is fully provided for, is a maximally regular dynamic system, ensuring the flow of definite chemical and energy producing processes, i.e., the regular course of metabolism. A decrease in the activity of the centers in narcosis leads to a disturbance of the regularity, i.e., to the disintegration of the extensive common energy levels into a series of discrete energy states.

Judging by the marked predominance of the narrow spectral bands, it is changes of this type which are observed in the molecular substratum in the first weeks after partial deafferentation of the heart muscle of the cat. They are evidently associated with a decrease in the flow of afferent impulses from the heart, and hence, with the inadequacy of the efferent influences arriving from the centers. Such changes in the substratum are unfavorable for the generation and spread of chain processes.

The results of the spectral analysis of the radiation 2 months after deafferentation of the heart show that within the first weeks processes of a compensatory character begin to take place in the substratum. Wider bands predominate in the spectrum or, in other words, foci of formation of unbalanced molecular regularity arise and grow into common energy levels.

The organization of regularity progresses with time – the spectra obtained 1 year after deafferentation are characterized by wider bands still.

It is this increasing widening of the bands observed despite the fact that the animals are under general anesthesia that makes the following interpretation so clearly possible. The compensatory processes lead to the construction of a rather less labile molecular organization of the substratum. A very slight change in lability may remain unnoticed during the active imposition of stimulation on the heart muscle, for example, during an increase in the rhythm of stimulation. However, in the reactions arising in response to a decrease in, or omission of, certain components of the complex interaction with the centers, these variations in the molecular organization of the substratum may become appreciable.

Hence the study of the radiation of the heart in experiments in vivo in normal and abnormal conditions leads to the following conclusions, characterizing certain parameters of the structural and energetic state of the molecular substratum essential for the general regulation of the processes of metabolism. Further work in this direction will show whether the bands in the spectrum of the heart can be identified with the spectra of certain intermediate products of metabolism, for example of mediators.

LITERATURE CITED

1. A. G. Gurvich and L. D. Gurvich, Mitogenetic Radiation [in Russian], Moscow (1945).
2. A. G. Gurwitsch and L. D. Gurwitsch, Die Mitogenetische Strahlung. Jena (1959).
3. A. A. Gurvich and V. F. Eremeev, Byull. Éksp. Biol., No. 6 (1966), p. 56.
4. Z. I. Sobieva, G. V. Chernysheva, N. B. Lavrent'eva et al., In: The Physiology and Pathology of the Circulation [in Russian], Moscow (1962), p. 51.