

MORPHOLOGY AND PATHOMORPHOLOGY

INFLUENCE OF PHYSICAL LOADINGS ON THE HISTOCHEMICAL CHANGES IN THE ACTIVITY OF SUCCINIC DEHYDROGENASE, ALKALINE PHOSPHOMONOESTERASE, AND ADENOSINE TRIPHOSPHATASE OF THE MYOCARDIUM, LIVER, AND KIDNEYS

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S. N. Sergeev (Moscow)

(Presented by Member of the Academy of Medical Sciences, USSR, A. V. Lebedinskii)

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The study of the morphological changes that occur during acute fatigue of the organism has pertained mainly to the nature of the structural disturbances of the myocardium [1, 4]. In the literature there are only single observations of the influence of increased physical loading on the histochemical changes in the enzyme activity in the internal organs; moreover, the object of investigation in these studies was the myocardium of the ventricles [2, 3, 8]. The data of histochemical investigations of changes in the enzyme activity in other internal organs during fatigue of the organism have not been published.

We conducted an experimental study of the histochemical changes in the activity of certain enzymes in the myocardium of the ventricles, as well as the liver and kidneys during acute fatigue of the organism.

PROCEDURE

The experiments were conducted on 24 sexually mature albino rats (12 experimental and 12 control). Fatigue of the animals was caused by swimming in water with a load of 12 g (10 min). Immediately after swimming, the rats were killed by decapitation. When the killed rats were autopsied, the same organs from the experimental and control animals were mounted on the microtome stage in one block and frozen with dry ice, which made it possible to obtain a single slice from two identical organs of experimental and control rats, killed simultaneously and thus to carry out a comparative investigation of the changes in the enzyme activity (here we equalized the influence of such factors as different thickness of the slices, quality of the reagent and working solutions, etc.). The slices of fresh unfixed tissue, 10 μ thick were prepared in a cryostat at a temperature of -18° and applied on microscope slides. A histochemical study was made of the changes in the succinic dehydrogenase, alkaline phosphomonoesterase, and adenosine triphosphatase activities. The succinic dehydrogenase activity was investigated with nitro ST (tetrazolium nitroblue) according to Nachlas [6], alkaline phosphomonoesterase—with sodium β -glycerophosphate according to Gomori [5], and adenosine triphosphatase according to Wachstein and Meisel [8].* The control slices were incubated without the substance. To obtain preparations for scanning, the slices were stained with hematoxylin-eosin and scarlet red (for fats).

RESULTS

A microscopic investigation of the myocardium of the control rats reveals high succinic dehydrogenase activity, related to the structure of the muscle fibers: the fine and larger formazan granules were bonded to the sarcomeres, and transverse and longitudinal striation of the muscle fibers was distinctly revealed. In the myocardium of most of the experimental animals, some increase in the succinic dehydrogenase activity was noted on account of an increase in the number of muscle fibers containing diformazan grains. Such muscle fibers, with an increased diformazan content, as well as small groups of them, could be seen in all portions of the myocardial slice. In certain

* The investigation procedure is set forth in detail in E. Pearse's monograph, "Histochemistry." (Izd. IL, Moscow, 1962).

experiments, these fibers were more often encountered in the middle layers of the myocardium and under the epicardium. The nature of the distribution of alkaline phosphomonoesterase activity in the myocardia of the experimental animals proved to be the same as in the controls. In the determination of the adenosine triphosphatase activity in the cytoplasm and nuclei of the muscle fibers of the myocardium, it was found that the walls of the fine blood vessels and intermuscular capillaries were distinguished by a high content of the enzyme. In most of the experimental animals, some decrease in the amount of lead sulfide in the sarcoplasm of the muscle fibers was observed. The enzyme activity in the nuclei of the muscle fibers, as well as in the walls of the fine blood vessels and intermuscular capillaries, continued to remain high.

In a microscopic investigation of liver tissue, high succinic dehydrogenase activity was revealed in the cytoplasm of the parenchymatous cells. The cells situated along the periphery of the lobes of the liver, around the septal veins, were distinguished by an increased deposition of diformazan. In most of the experimental animals, some inhibition of the succinic dehydrogenase activity was established, predominantly in the central portions of the lobes of the liver, with a high content of the enzyme along the periphery of the lobes. In the reaction for alkaline phosphomonoesterase, no distinct changes in the distribution of the enzyme activity in the experimental animals could be noted.

The adenosine triphosphatase activity in the liver was determined both in the cytoplasm of the parenchymatous cells and in the walls of the bile capillaries; moreover, the latter were distinguished by a very high content of the enzyme. In the experimental animals, in half the cases an increase in the enzyme activity was observed in the liver, expressed in an increase in the amount of lead sulfide in the cytoplasm of the parenchymatous cells. The enzyme activity in the walls of the bile capillaries also remained rather high.

In the kidneys, succinic dehydrogenase was detected in large quantities in the epithelium of the convoluted tubules, and in somewhat smaller amounts in the straight tubules. The epithelium of the convoluted tubules was distinguished by a high alkaline phosphatase content. The adenosine triphosphatase activity was determined both in the epithelium of the tubules and in the epithelium of the glomeruli. No changes in the nature of the distribution of the activities of the enzymes studied were determined in the kidneys of the experimental animals.

Thus, our histochemical investigation of the changes in the activities of succinic dehydrogenase, alkaline phosphomonoesterase, and adenosine triphosphatase in the liver, kidneys, and myocardium of the ventricles of rats during acute fatigue made it possible to detect early changes in the succinic dehydrogenase and adenosine triphosphatase activities. At the same time, a relatively higher stability of the alkaline phosphomonoesterase in the organs studied was detected in this experiment; however, no morphological changes could be established in these organs using the usual methods of histological treatment of tissue.

The early histochemical changes in the myocardium and liver that we detected are evidence of lability of the enzyme systems participating in the accomplishment of the oxidative processes and metabolic energy reactions of the organism, and a rapid reaction in response to an increase in the physical loading and the related fatigue of the organism.

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