CHANGES IN LACTIC AND PYRUVIC ACID LEVELS IN THE MYOCARDIUM DURING ELECTRICAL STIMULATION OF THE AORTIC REFLEXOGENIC ZONE

V. P. Isachenko
and N. A. Novikova

UDC 612.173.1-06:612.178.6

The pyruvic and lactic acid levels in the blood and myocardial tissue were investigated in male albino rats weighing 250-300 g during the development of neurogenic degeneration induced by electrical stimulation of the aortic reflexogenic zone. Under these conditions the blood pyruvic and lactic acid levels were increased. In the myocardial tissue the lactate concentration rose, indicating stimulation of glycogen breakdown by glycolysis in the heart muscle tissue in response to electrical stimulation of the aortic reflexogenic zone producing myocardial degeneration.

The state of the sympathetic nervous system and the catecholamine level are now known to play an essential role in the development of degeneration during application of an extraordinary stimulus [1, 3, 4, 6]. Catecholamines participate in the regulation of various types of metabolism, notably carbohydrate metabolism. Disturbance of the catecholamine balance may lead to metabolic disorders which, in turn, may give rise to tissue destruction.

In the investigation described below some indices of carbohydrate metabolism, namely the lactic and pyruvic acid levels, in the myocardium were studied during stimulation of receptors in the aortic arch.

EXPERIMENTAL METHOD AND RESULTS

Experiments were carried out on 70 male albino rats weighing 250-300 g. Extraordinary stimulation was applied to the animals directly to the aortic reflexogenic zone by Vedeneeva's method [5]. Under ether anesthesia a thin electrode insulated with polyethylene was introduced through the right common carotid artery of the rats into the aortic arch. Electrical stimulation of the aortic arch was carried out by means of square pulses (50 Hz, 5-7 V), generated by a type IG-6 electronic stimulator, for periods of 15 min, 1 h, and 3 h. Some animals were sacrificed immediately after electrical stimulation, others 24 h after electrical stimulation lasting 3 h. Intact rats and animals immobilized and with the electrode introduced into the aortic arch, but not stimulated, acted as the controls. The levels of pyruvic [2] and lactic [7] acids were determined in the blood and myocardial tissues of all the animals.

The results showed that after electrical stimulation of the aortic arch for 15 min there was a marked increase in the blood levels of pyruvic and lactic acids, which reached a maximum after stimulation for 1 h (Fig. 1). After stimulation for 3 h the pyruvic acid concentration did not differ significantly from that in intact animals. Meanwhile the lactic acid level was a little below its initial value 24 h after electrical stimulation of the aortic arch for 3 h.

A marked decrease (by 46%) in the pyruvic acid level was observed in the myocardial tissue after stimulation for 15 min, and this decrease persisted after stimulation for 1 h (Fig. 2). However, later in the course of the investigation the pyruvic acid level rose to reach that observed in the intact animals.

Department of Pharmacology, Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, Leningrad. (Presented by Academician of the Academy of Medical Sciences of the USSR, S. V. Anichkov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 73, No. 4, pp. 47-49, April, 1972. Original article submitted December 8, 1970.

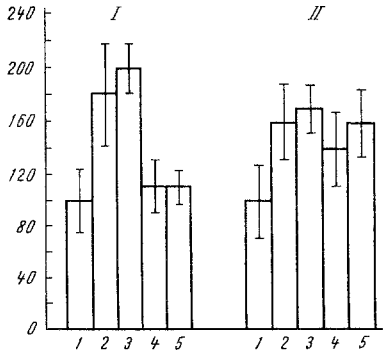

Fig. 1

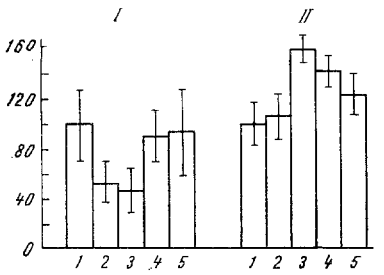

Fig. 2

Fig. 1. Concentration of pyruvic (I) and lactic (II) acids in the blood during electrical stimulation of the aortic reflexogenic zone (in percent of corresponding index in intact rats): 1) intact animal; 2) after electrical stimulation for 15 min; 3) for 1 h, 4) for 3 h; 5) 24 h after end of electrical stimulation lasting 3 h. Vertical lines show confidence intervals.

Fig. 2. Pyruvic (I) and lactic (II) acid levels in myocardium during electrical stimulation of aortic arch. Legend as in Fig. 1.

Meanwhile the lactic acid concentration in the myocardium showed no significant change after stimulation for 15 min, but was significantly (by 60%) increased after stimulation of the aortic arch for 1 h (Fig. 2). Accumulation of lactate in the myocardium also was observed after stimulation for 3 h. The lactic acid concentration in the myocardium 24 h after electrical stimulation for 3 h was not significantly different from its initial level. Immobilization of the animal and introduction of the electrode into the aortic arch produced no significant changes in these parameters. Since the ratio between the lactic and pyruvic acid levels reflects a shift of equilibrium toward glycolysis or toward oxidation, this ratio was calculated. After electrical stimulation for 15 min it was increased by 90%, and it reached a maximum (230%) after stimulation for 1 h. Later this ratio fell, but it still remained higher than in the intact animals. For instance, immediately after stimulation for 3 h the ratio was increased by 60%, and 24 h later it was increased by 40%.

It can be concluded from these results that during application of an extraordinary stimulus to the aortic reflexogenic zone there is a switch from the aerobic to the anaerobic pathway of carbohydrate breakdown. Evidence of this is given by the decrease in the pyruvic acid level and increase in the lactic acid level in the myocardium. The accumulation of lactate at subsequent stages of the investigation is evidence of a marked shift of equilibrium toward the breakdown of glycogen by glycolysis. It can be considered that this effect depends on the liberation of large quantities of catecholamines at the time of application of the extraordinary stimulus to the reflexogenic zone of the animal's aorta, for catecholamines are known to induce the accumulation of lactate in the myocardial tissues [8]. As the reserves of catecholamines in the myocardial tissue are exhausted (after stimulation for 3 h) this effect becomes weakened, and this is reflected by restoration of the pyruvic acid level and by some decrease in the accumulation of lactate in the tissues.

LITERATURE CITED

1. S. M. Anichkov, I. S. Zavodskaya, E. V. Moreva, et al., Neurogenic Degenerations and Their Pharmacotherapy [in Russian], Leningrad (1969).
2. Biochemical Methods of Clinical Investigation [in Russian], Moscow (1969), p. 255.
3. Z. I. Vedeneeva, Byull. Éksperim. Biol. i Med., No. 12, 38 (1960).
4. Z. I. Vedeneeva, Farmakol. i Toksikol., No. 3, 286 (1962).
5. I. S. Zavodskaya and E. V. Moreva, Kardiologiya, No. 7, 73 (1968).
6. I. S. Zavodskaya and E. V. Moreva, Kardiologiya, No. 7, 73 (1968).
7. M. I. Prokhorova and Z. N. Tupikova, Large Practical Manual of Carbohydrate and Lipid Metabolism [in Russian], Leningrad (1965), p. 81.
8. M. E. Raiskina, The Biochemistry of Nervous Regulation on the Heart [in Russian], Moscow (1962).