FUNCTIONAL STATE AND RESERVE CAPACITY OF THE HEART MUSCLE OF RABBITS WITH EXPERIMENTAL RENAL HYPERTENSION

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The kidneys are a central component in the regulation of the arterial pressure and they play one of the most important roles in the development of hypertension of whatever etiology [6, 10]. The hypertrophied myocardium needs a greater blood supply than the normal heart muscle. When increased demands are presented to the pathologically changed heart, it is possible that coronary insufficiency may develop [4, 7-9].

The object of this investigation was to study the contractile function and reserve capacity of the myocardium of animals with experimental renal hypertension.

EXPERIMENTAL METHOD

Experiments were carried out on 64 sexually mature rabbits weighing 2.5-3.5 kg (24 with experimental renal hypertension and 40 healthy animals).

Experimental renal hypertension was produced by application of rubber caps to the kidneys in successive stages by Page's method in the writer's modification [1]. Chronic and acute experiments were conducted on animals with hypertension. In chronic experiments on waking rabbits the arterial pressure was measured by the palpation method of Riva–Rocci in the carotid artery, previously exteriorized in a skin flap in the neck by Van Leersum's method. To carry out phase analysis of the cardiac cycle, synchronized recordings were obtained of the electrocardiogram (ECG), phonocardiogram, seismocardiogram, and the sphygmogram of the coronary artery, on the 4ÉÉG-1 electroencephalograph. Mechanical oscillations of the wall of the carotid artery were transformed in a closed pneumatic system by means of a piezoelectric transducer and led to one channel of the recorder. By connecting capacitors of between 0.1 and 0.5 μF high-frequency oscillations were removed and the freedom from interference of the detector was improved. Phase analysis of the cardiac cycle was carried out on the basis of polycardiograms [3]. Besides the classical phases and parameters of the cardiac cycle, the reserve (ratio of the diastolic period to the phase of contraction) and intraphase (ratio of the duration of systole to diastole) indices were calculated. To study the reserve capacity of the myocardium in acute experiments, the aorta was repeatedly

TABLE 1. Dynamics of Arterial Pressure (in mm Hg) in Rabbits with Renal Hypertension (M ± m)

Stage of experiment	Systolic arterial pressure	Difference, %	P
Initial data	92±2		
Arterial hypertension, months:			
1	155±7	+69	<0,001
2	170±7	+85	<0,001
3	170±5	+85	<0,001

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TABLE 2. Dynamics of Phases and Indices of Cardiac Cycle in Animals with Renal Hypertension (C = 0.232 sec)

Stage of experiment	Phases and indices of cardiac cycle						
	T, sec	E, sec	D, sec	ISI, %	IMT, %	RI	P–T, sec
Expected values	0,050	0,100	0,085	87	32	1,8	0,231
Hypertension	0,082	0,065	0,083	60	56	1,1	0,205
Difference, %	+64	—35	—2	—31	+75	—40	—11

Legend. E) Phase of expulsion, D) diastole, ISI) intrasystolic index, IMT) index of myocardial tension, RI) reserve index, P-T) time from beginning of P wave to end of T wave of ECG.

TABLE 3. Some Hemodynamic Indices of Intact and Experimental (with renal hypertension) Rabbits (M ± m)

Index	Group of animals		Difference, %	P
	intact	with arterial hypertension		
Pulse pressure, mm Hg	35±3	59±5	+68	<0,01
Systolic pressure in left ventricle, mm Hg	80±4	159±10	+99	<0,001
Diastolic pressure in left ventricle, mm Hg	—22±4	—29±6	—38	>0,05
ΔP/Δt, mm Hg/sec	832±75	1850±80	+122	<0,05
IFS, mm Hg/g	18,2±1,4	27±5	+49	>0,05
IS, g^{-1}	10,6±1,3	11,5±1	+19	>0,05

compressed [5]. Pressure signals were transformed by means of electromanometers and amplified by a TAP-5 strain guage. The speed of the tape-winding mechanism was 160 mm/sec.

EXPERIMENTAL RESULTS

In all animals with experimental renal hypertension a high and stable level of systolic and diastolic pressure (Table 1) was observed, with a shift in the phase structure of the cardiac cycle, in the form of a high diastolic pressure syndrome (Table 2). At the stage of formation of renal hypertension [7] the phase of tension (T) was lengthened mainly on account of the phase of isometric contraction. The reserve capacity of the myocardium was reduced, as shown by a decrease in the reserve index (RI) on account of a change in the tension phase. The velocity of conduction of excitation along the conducting system of the heart and the ventricular myocardium was increased ($P < 0.05$). During the development of renal hypertension the rate of rise of pressure in the left ventricle ($\Delta P/\Delta t$) was increased by 122% compared with the control.

An increase in the pulse pressure and in the rate of pressure in the left ventricle indicated an increase in the contractile power of the myocardium of the animals with experimental renal hypertension (Table 3). Meanwhile, the increase in the intensity of function of the myocardial structures (IFS) was not significant ($P > 0.05$).

The results are evidence of potentiation of the inotropic state of the heart muscle of rabbits in the stage of formation of experimental hypertension. Similar changes in the early stage of arterial hypertension were observed by Shkhvatsabaya [10]. Relatively high myocardial contractility of animals with arterial hypertension is evidently connected with

a special type of adaptation to the gradual increase of resistance in the arterial system. Compensatory hyperfunction of the myocardium of rabbits with arterial hypertension was homeometric in its type of development. The rapid rise of pressure in the ventricles enabled the cardiac frequency to be increased without impairment of filling of the heart with blood during systole. However, the reserve capacity of the hypertrophied myocardium was found to be limited, as shown by experiments with compression of the animals' aorta. Under isometric conditions of work of the myocardium, the "ladder of fatigue" [5] developed faster in the animals with a hypertrophied myocardium. Compression of the aorta evoked much less excitation of the sympathetic nervous system [2, 5] in animals with arterial hypertension than in intact animals. Constant and prolonged hyperfunction of the myocardium evidently led to partial exhaustion of the reserves of the sympathico-adrenal system.

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PREVENTION OF DISTURBANCES OF MYOCARDIAL CONTRACTILITY ARISING AFTER EMOTIONAL PAIN STRESS BY γ-HYDROXYBUTYRIC ACID AND THE ANTIOXIDANT IONOL

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The excess of catecholamines in the blood arising under the influence of emotional pain stress leads to activation of lipid peroxidation and to the accumulation of lipid hydroperoxides in the heart muscle and other organs [5]. The harmful action of these peroxidation products leads to increased outflow of enzymes from the heart muscle [4] and to the development of focal lesions of contracture type in the myocardium [1].

It has also been shown that these stress-induced lesions in the heart can be completely prevented, first, by inhibition of the response to stress itself with the aid of the inhibitory metabolite γ-hydroxybutyric acid (GHBA), which acts at the brain level [1, 2] and, second, with the aid of the antioxidant ionol, an inhibitor of peroxidation, which acts mainly at the level of the heart and of other target organs [4]. Besides the disturbances of cardiac metabolism mentioned above in animals exposed to emotional pain stress (EPS),

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