metabolism of an organ subjected to prolonged ischemia; however, the duration of inhalation, other methods of creating hypoxemia and, in particular, the search for ways of inducing local hypoxemia, require further investigation.

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COMPARISON OF THE PROTECTIVE EFFECT OF ADAPTATION TO SHORT-TERM STRESS AGAINST INJURY TO THE HEART AND PORTAL VEIN BY LONG-TERM STRESS

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Long-term stress causes marked disturbances of contractility of the heart and capacitive vessels [2]. Stress injury to the myocardium has been shown to be preventable by preliminary adaptation of animals to daily short exposures to stress [3]. The protective effect of intensive adaptation of this kind is incomplete and it has its "price," i.e., adaptation itself causes the significant depression of myocardial contractility.

In the present investigation, besides the protective effect of daily (intensive) adaptation, the effect of gentle adaptation, in which short exposures to stress were given on alternate days, also was studied. Since vascular injury in long-term stress has been shown to be more severe than the disturbance of myocardial function after exposure to the same kind of stress [4] the main aim of this investigation was to compare the protective effect of preliminary adaptation on disturbance of contractile function of the right atrial myocardium and the smooth muscle of the portal vein arising during long-term stress.

EXPERIMENTAL METHOD

Experiments were carried out on male Wister rats weighing 200-280 g in two stages. In the first stage the effect of preliminary intensive adaptation of the animals to stress on disturbance of contractile function of the myocardium and vascular smooth muscle arising during long-term stress was studied. Intensive adaptation

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TABLE 1. Effect of Preliminary Intensive Adaptation on Disturbance of Contractile Function of Atrium and Portal Vein Due to Long-Term Stress (M±m)

Series of experiments	Right atrium		Portal vein	
	Developed force, mg force	Frequency of contractions per minute	Developed force, mg force	Frequency of contractions per minute
I. Control (n=8)	279±25	256±8,0	233±24	5,3±0,6
II. Stress (n = 9)	152±12	233±6,0	74±6,6	4,9±0,4
III. Adaptation	199±23	235±6,1	131±17	6,2±0,3
IV. Adaptation + stress (n = 9)	281±19	205±6,2	149±20	5,0±0,4
P_{I-II}	<0,01	<0,05	<0,01	n.s.
P_{I-III}	<0,05	n.s.	<0,01	n.s.
P_{I-IV}	n.s.	<0,01	<0,02	n.s.
P_{II-IV}	<0,01	<0,01	<0,01	n.s.
P_{III-IV}	<0,05	<0,1	n.s.	<0,05

Legend. Here and in Table 2: n) number of animals in series; n.s.) differences not significant.

was undertaken by immobilizing the rats daily in the supine position: for 15 min the first time, for 30 min the second time, and for 1 h on the next ten days.

In the second stage the protective effect of gentle adaptation by immobilizing the animals on alternate days was studied: for 15 min the first time, for 45 min the second time, for 1 h on each of the next four times. At each stage of the investigation four series of experiments were carried out: I) control, intact animals; II) stress – the animals were subjected to prolonged immobilization stress for 6 h ; III) adaptation – the animals were adapted to short-term stress; IV) adaptation + stress – after a course of adaptation the animals were subjected to long-term immobilization stress. The rats were decapitated 2 h after the end of a 6-h exposure to stress. The adapted animals were used in the experiments 24 h after the end of the course of adaptation. The isolated right atrium was used to study the contractile function of the myocardium. The isolated atrium was placed in a constant-temperature bath containing oxygenated Krebs–Henseleit solution (95% O_2 + 5% CO_2, pH 7.4, 34°C); the base of the atrium was fixed immovably, while the apex of the auricle was connected to the F-50 myograph of a DMP-4B physiograph (Narco Bio-Systems, USA). The atrium contracted spontaneously for 40-50 min, after which it was gradually stretched to the length at which it developed maximal tension under isometric conditions. Spontaneous contractile activity of the isolated portal vein was recorded under conditions of isometric contraction by means of a two-channel system (Ugo Basile, Italy). Immediately after decapitation of the animals the portal vein was removed and placed in a constant-temperature chamber with oxygenated Krebs' solution (95% O_2 + 5% CO_2, pH 7.4, 32°C) and stretched by a weight of 400 mg. The portal vein was kept under these conditions for 1 h before the beginning of the experiment in order to stabilize spontaneous contractions. Parameters of contractility of the atrium and portal vein were calculated: the developed force and spontaneous contraction rate.

The results were subjected to statistical analysis by Student's test.

EXPERIMENTAL RESULTS

The results obtained in the first stage of the investigation (Table 1) showed that long-term immobilization stress depressed myocardial contractility by 1.8 times, and contractility of the portal vein more than threefold. This result agrees with those of previous investigations using a different model of stress [4] and is evidence that the vascular smooth muscle is less resistant than the myocardium to the action of stress. Intensive adaptation had its "price," i.e., it led by itself to marked depression of the contractile function of the muscles. Incidentally, the "price" of adaptation relative to developed force of contractions was 44% for the vein and 24% for the atrium, i.e., it was almost twice as much for the vein. This is further evidence of the greater vulnerability of the portal vein compared with the myocardium. Stress also did not cause any significant depression of function of the organs of animals adapted to short-term stress, and preliminary adaptation had a significant protective action (Table 1).

TABLE 2. Effect of Preliminary Gentle Adaptation on Disturbance of Contractile Function of atrium and Portal Vein Due to Long-Term Stress (M±m)

Series of experiments	Right atrium		Portal vein	
	Developed force, mg force	Frequency of contractions per minute	Developed force, mg force	Frequency of contractions per minute
I. Control (n=10)	343±15	258±8,0	139±10	7,8±1,7
II. Stress (n = 9)	181±20	251±8,0	59±9,1	8,9±1,5
III. Adaptation (n=8)	420±21	240±4,9	136±11	10,0±0,7
IV. Adaptation + stress (n = 8)	311±32	249±8,0	109±12	9,5±12
P_{I-II}	<0,01	n.s.	<0,01	n.s.
P_{I-III}	<0,05	n.s.	n.s.	n.s.
P_{I-IV}	n.s.	n.s.	n.s.	n.s.
P_{II-IV}	<0,01	n.s.	<0,01	n.s.
P_{III-IV}	<0,05	n.s.	n.s.	n.s.

Long-term adaptation to widely different factors, including to stress, is known to be based on a memory effect and, in particular, brain memory [1], which may often be more effective if infrequent exposures are given at longer intervals than when exposures are too frequent [5]. Taking this into consideration, in the next stage of the investigation an attempt was made to make the conditions of adaptation more gentle, by reducing by half the number of exposures to stress and by lengthening the intervals between them.

The results obtained at this stage (Table 2) indicate that gentle adaptation did not depress the contractile function either of the heart or of the portal vein, i.e., it had no perceptible "price." The contractile function of the myocardium and portal vein of animals exposed to stress for 6 h after preliminary gentle adaptation did not differ significantly from that in the control. Protection was virtually complete. The fact will be noted that long-term stress, after adaptation under these conditions, even in the portal vein, which is highly susceptible to its injurious action, caused only a small decrease, which was not significant, in the parameters of contractility.

According to existing views, the protection action of preliminary adaptation is based on an increase in the power of the central and cellular systems of the body that limit the stress reaction, i.e., on increased efficiency of the enzymes responsible for the formation of GABA, endorphins, and enkephalins in the brain, and also of natural antioxidants, prostaglandins, and adenosine in the effector organ [1]. If such adaptation takes place under rigorous conditions, its structural "price" will be high. In the present experiments this was shown by depression of the contractile function of the organs studied in animals adapted under intensive conditions. The use of a gentle adaptation schedule enabled the undesirable "price" of adaptation to be avoided, and thus made protection maximally effective. Stress-induced disturbances of function both of the atrium and of the more vulnerable portal vein could be prevented virtually completely in this way.

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