DISTURBANCES OF THE ADRENERGIC INNERVATION OF THE STOMACH IN RATS WITH STABLE CONTROL OF CARDIOVASCULAR FUNCTIONS DURING EMOTIONAL STRESS

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Analysis of the dynamics of the blood pressure and heart rate in Wistar rats during acute immobilization stress revealed stability of the cardiovascular function during emotional stress. Meanwhile these animals showed increased sensitivity of the adrenergic component of the sympathetic and parasympathetic innervation of the stomach, as a result of which degenerative changes developed in that organ. Emotional stress was found to be accompanied by successive phases of disturbances of adrenergic innervation: mobilization of adrenergic innervation alternated with its exhaustion.

KEY WORDS: *emotional stress; arterial hypertension; adrenergic innervation of the stomach.*

Emotional stress [1, 10, 12] is the leading cause of many different disturbances of visceral functions, notably disturbances of the cardiovascular system.

However, previous investigations [13] showed that among rats of different inbred strains there are some groups of animals, especially Wistar strains, which are resistant to disturbance of cardiovascular functions in emotional stress due to immobilization. Accordingly the problem arises: is the stability thus revealed absolute, applicable to all visceral functions, or can the manifestations of emotional stress in these animals extend to the activity of other internal organs and, in particular, to the gastrointestinal tract.

To shed light on this problem, in the investigation described below the state of the adrenergic innervation of the stomach was studied in a group of Wistar rats with stable regulation of cardiovascular functions during emotional stress caused by immobilization.

EXPERIMENTAL METHOD

Fifteen male Wistar rats weighing 250 g were used. Emotional stress was induced by immobilizing the animals in a restrictive chamber for 30 h. Throughout the experiments, on 8 immobilized rats and 4 control rats kept in ordinary cages under conditions of free behavior, the blood pressure was recorded dynamically through a catheter inserted into the caudal artery [11].

The state of the adrenergic innervation of the stomach was studied in 15 rats, of which 8 were experimental, 4 control, with catheters inserted for measuring the blood pressure, and 3 were intact.

The animals were killed by decapitation. The state of the gastric mucosa was assessed visually, after which sections were cut for histochemical processing by the method of Falck and Owman [16] in Krokhina's modification [6]. Unmounted sections were studied in the luminescence microscope.

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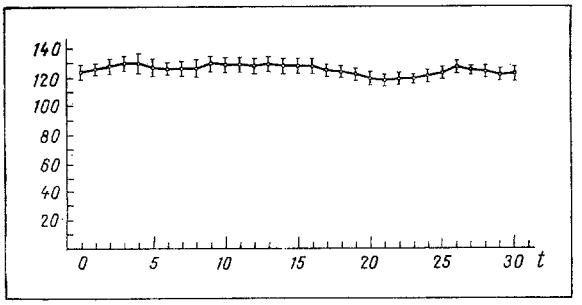

Fig. 1. Averaged (8 rats) dynamics of blood pressure during emotional stress caused by immobilization for 30 h, demonstrating stability of cardiovascular functions in experimental group of Wistar rats. Ordinate, mean arterial blood pressure, mm Hg; abscissa, time, in h.

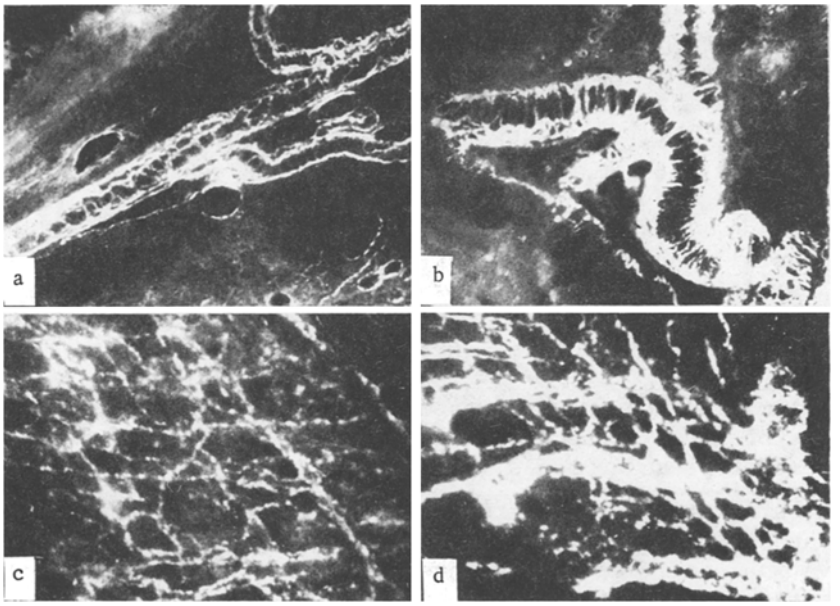

Fig. 2. Activation of adrenergic innervation of rat stomach during emotional stress due to immobilization: a) adrenergic innervation of a blood vessel of gastric mucosa of intact rat, 120×; b) vessel with enriched adrenergic innervation from gastric mucosa of rat after emotional stress, 120×; c) adrenergic terminals in muscular nervous plexus of stomach of intact rat, 120×; d) numerous adrenergic terminals in muscular plexus of rats subjected to emotional stress, 120×.

EXPERIMENTAL RESULTS

Dynamic measurement of the blood pressure during immobilization for 30 h revealed stability of the cardiovascular functions during exposure to emotional stress in the whole group of experimental rats (Fig. 1). The blood pressure and heart rate of the rats of the experimental group were indistinguishable from those of the control group, kept under conditions of free behavior, throughout the experiment.

Histochemical investigation of the stomach showed that in 6 of the 8 rats whose movements were limited for 30 h mobilization of the adrenergic innervation was present in the stomach wall, as reflected in an increase in the number of adrenergic axons innervating all types of blood vessels (Fig. 2b). Many adrenergic axons also were discovered in the intramural muscular nervous plexus (Fig. 2d). Changes were found in the nerve fibers and endings in the stomach of the experimental animals: the sites of accumulation and storage of mediator grew larger and resembled varicosities. Along the length of the axons these varicosities became larger and more numerous, their distribution was more frequent, and if the brightness

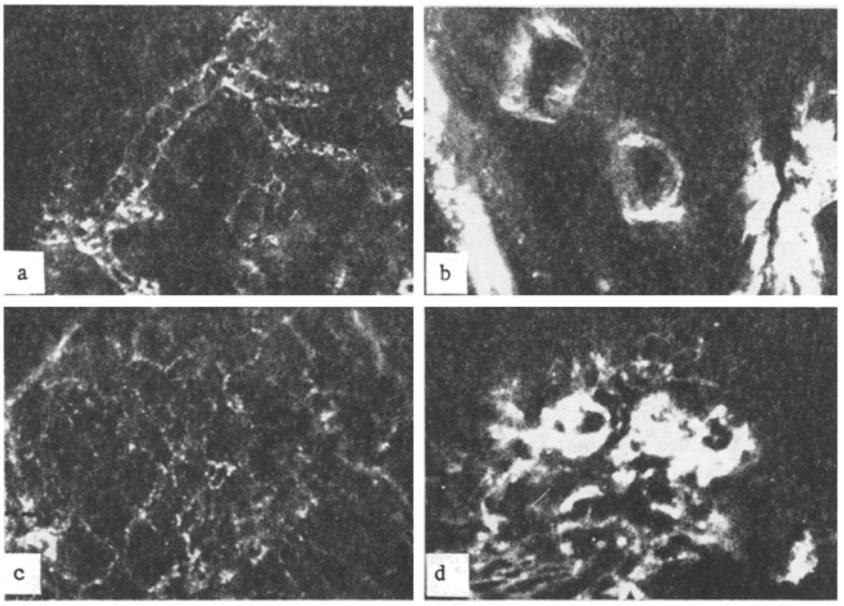

Fig. 3. Disturbances of adrenergic innervation of stomach of rats with emotional stress: a) blood vessel with poor adrenergic innervation from gastric mucosa of rat after emotional stress, 120×; b) vessels with no adrenergic innervation, from gastric mucosa of same rat, 120×; c) exhaustion of adrenergic terminals in intermuscular plexus of stomach of same rat, 120×; d) adrenergic neurons in Auerbach's plexus of stomach of rat during stress, 120×.

of their specific luminescence was increased as a result of the high concentration of mediator in them, groups of these axons in the intramural plexuses and ganglia had the appearance of brightly luminescent granular bands (Fig. 2d).

In one of the six rats multiple erosions and ulcers were found in the musoca of the pyloric part. The appearance of defects in the mucosa against the background of the activated adrenergic innervation confirmed data in the literature indicating that an excess of catecholamines, liberated into the innervated tissue, has a harmful action on it [2-10, 19, 20].

In 2 of the 8 immobilized rats the quantity of mediator in the adrenergic fibers of the stomach was exhausted. This was shown histochemically as a reduction in the number of adrenergic axons and in their caliber (Fig. 3a, b, c). Against the background of marked exhaustion of mediator in the sympathetic nerves of the stomach in one rat, numerous erosions, bleeding ulcers, and hemorrhages into the submucosa were found in the mucous membrane of the pyloric part of the stomach.

Exhaustion of catecholamines in organs in various stress states has been demonstrated biochemically by many investigators [2, 8, 15, 18]. No defects of the gastric mucosa were found in any of the seven control or intact rats.

Analysis of the experimental results described above shows that immobilization stress led to mobilization of the adrenergic innervation in some animals (75%) resistant to changes in cardiovascular functions, and to exhaustion of the adrenergic innervation in others (25%). Degeneration of the gastric mucosa was found in both groups of rats. It can accordingly be postulated that degeneration in the gastric mucosa develops against the background of activation of the adrenergic innervation, and should exposure to stress continue, the degeneration becomes more severe with exhaustion of the mediator in the adrenergic nerve structures.

Characteristically in rats subjected to emotional stress solitary adrenergic neurons and groups of them were found as a rule in the parasympathetic nerve ganglia of the intermuscular and submucous plexuses of the stomach (Fig. 3d). This is a fact of great interest since the presence of adrenergic neurons in the parasympathetic plexus of the stomach still remains a topic for discussion [17].

Adrenergic neurons in the intramural plexus of intact rats, as in other species of animals, are located with great difficulty for they have a very low level of mediator metabolism that cannot be detected histochemically [14]. After the concentration of mediator in the neurons has been increased by injection of exogenous noradrenalin, the adrenergic neurons of the intramural ganglia are easily found by luminescence microscopy [6, 7, 9].

Emotional stress in rats mobilizes catecholamine synthesis in the neurons of the autonomic plexuses of the stomach and thereby facilitates their histochemical detection.

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