Dilatory Humoral Adrenergic Reactions of Regional Veins and Arteries during Systemic Hypoxia and Hypothermia

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In experiments on anesthetized cats, perfusion of neurally decentralized vessels in the gastrocnemius muscle and small intestine with constant flow of autoblood containing isoproterenol induced dilator reactions in arteries and veins. Against the background of hypoxic hypoxia, the reactions of arteries and veins in the gastrocnemius muscles and veins in small intestine attenuated, although the arterial reactions in the latter region did not change. Total hypothermia (30°C) attenuated the dilator reactions in regional vessels. Under the combined action of hypoxia and hypothermia, the amplitudes of dilator reactions of muscle vessels and intestine veins were equal to the baseline values, although the responses of intestinal arteries were pronouncedly weakened. It is concluded that blood vessels in the gastrocnemius muscle and veins in the small intestine possess positive resistance to whole-body hypoxia and hypothermia.

Key Words: *arterial and venous dilation; gastrocnemius muscle; small intestine; hypoxia, hypothermia*

The effects of hypoxia and hypothermia (HT) on humoral and adrenergic reactions of blood vessels were studied predominantly in experiments with large arterial rings treated with epinephrine, *i.e.* under conditions when factors were applied separately [7-9]. Despite the fact that artificial hybernation is widely used in surgery to protect the organs and tissues from hypoxic damage, there are few analytical studies on the combined effects of whole-body hypoxia and HT on adrenergic sensitivity of smooth muscles in veins and arteries [6]. It was previously found that responses of veins and arteries in feline gastrocnemius muscle (GCM) and small intestine to exogenous norepinephrine changes in different manner under conditions hypoxia, HT, or their combination [3]. This probably attests to a protective effect of total cooling (30°C) against hypoxic influences on adrenergic reactivity of intestinal veins, because sensitivity of venous myocytes practically did not change. Similar observations were made in arteries of both organs. Therefore, it seems advisable to continue the study of dilator adrenergic reactions of regional veins and arteries with the same method.

Our aim was to examine individual and combined effects of hypoxia and HT on adrenergic dilator reactions of veins and arteries in feline GCM and small intestine.

MATERIALS AND METHODS

Experiments were carried out on 14 cats weighing 2-4 kg narcotized with Nembutal (sodium etaminal, 30-40 mg/kg intramuscularly). GCM (crus preparation) and small intestine (jejunum and ileum) were hemodynamically and neurally isolated and perfused with constant flow of autoblood. The methods of arterial and venous resistography [1,2,10] were used to evaluate changes in blood flow resistance in arte-

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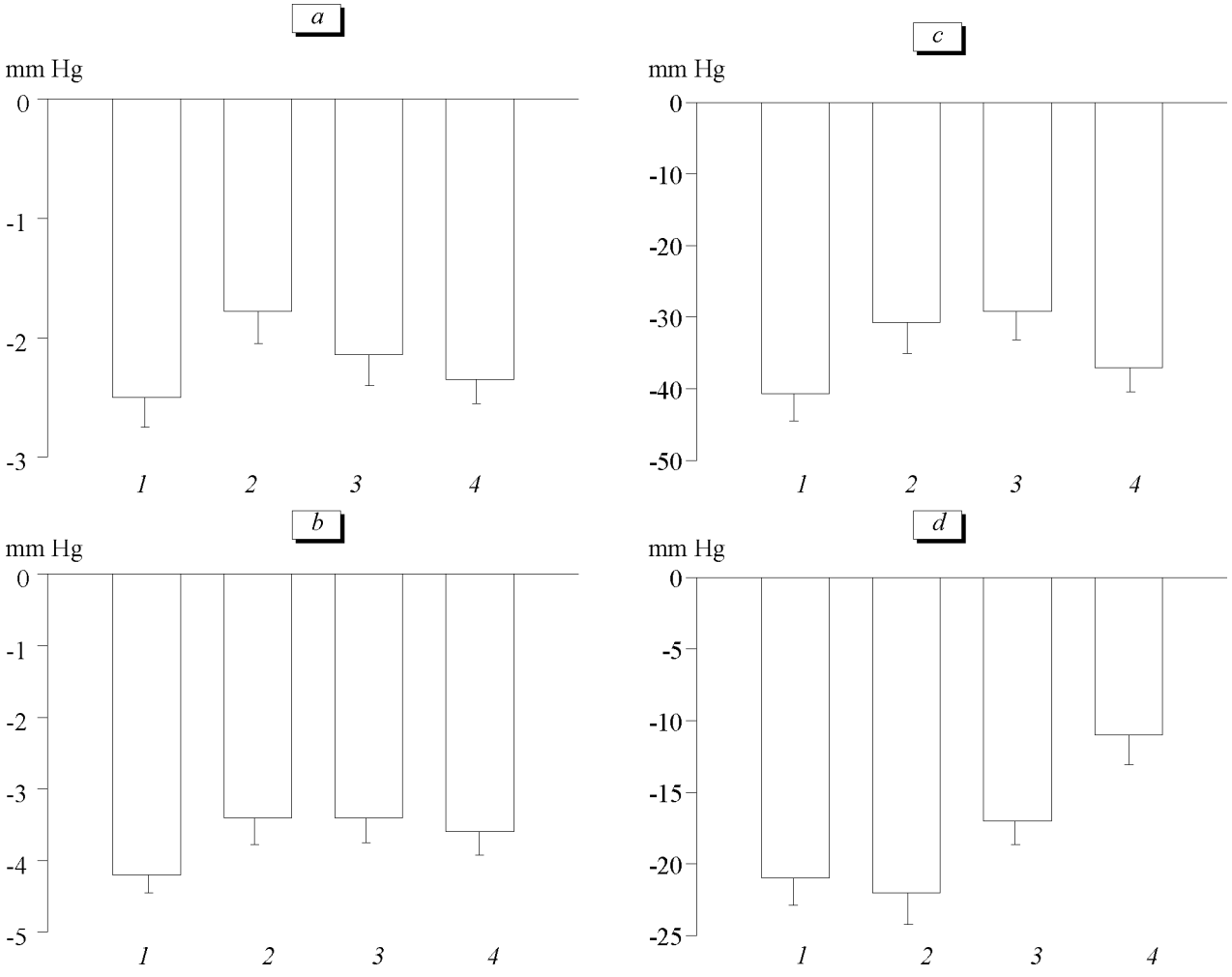

Fig. 1. Individual and combined effects of whole-body hypoxia and hypothermia on dilator reactions induced by isoproterenol in veins (*a*, *b*) and arteries (*c*, *d*) of gastrocnemius muscle (*a*, *c*) and small intestine (*b*, *d*). Ordinate: venous (*a*, *b*) and arterial (*c*, *d*) perfusion pressure. *1*) baseline, *2*) hypoxia, *3*) hypothermia, *4*) hypoxia+hypothermia.

ries and veins in each organ in response to intra-arterial bolus injection of isoproterenol in 0.1 ml 6% dextran (Poliglyukin) performed during normothermia and normoxia, during hypoxia (inhalation of 10% O_2 and 90% nitrogen mixture, the measurement were performed at stimulation minute 10), during cooling of the organism to 30.0±0.3°C at a rate of 0.07±0.02°C/min), and during combined hypoxia and HT. Heparin (1500-2000 U/kg intravenously) was used to prevent blood coagulation in the perfusion system. Cooling was performed in a chamber with water circulating at 0°C.

The results were analyzed statistically using Student's *t* test at $p<0.05$.

RESULTS

During normoxia and normothermia, isoproterenol decreased venous perfusion pressure by 2.5±0.5 mm Hg and 4.2±0.5 mm Hg in GCM and small intestine, respectively. Hypoxia decreased the amplitudes of venous reactions to isoproterenol in GCM and small intestine (Fig. 1, *a*, *b*). The amplitudes of dilator reactions returned to the baseline 10-15 min after cessation of hypoxia. Total cooling produced little effect on the amplitude of dilatory adrenergic reactions in regional veins: dilator reactions in both examined regions tended to decrease (Fig. 1, *a*, *b*). The combination of hypoxia and HT produced no effect on the sensitivity of smooth muscles on regional veins to isoproterenol: the amplitudes of dilator reactions little differ from the initial values (Fig. 1, *a*, *b*). These findings indicate that hypoxia in combination with total cooling did not modulate the reactions of regional veins to isoproterenol in contrast to hypoxia applied during normothermia.

When injected into regional blood flow under normal conditions, isoproterenol decreased arterial perfusion pressure in GCM and small intestine by 40.7±7.9 mm Hg and 21.0±7.9 mm Hg, respecti-

vely. Hypoxia and HT alone decreased dilator reactions of GCM arteries to isoproterenol (Fig. 1, c). By contrast, hypoxia increased the amplitude of dilator adrenergic reactions in small intestinal arteries, while HT produced an opposite effect on these vessels (Fig. 1, *d*). Combined application of hypoxia and HT produced no changes in adrenergic reactivity of GCM arteries, where the amplitudes of dilator reaction did not differ from the control. At the same time, combined application of hypoxia and HT markedly decreased (2-fold) the responses of small intestinal arteries to isoproterenol (Fig. 1, *d*).

Thus, whole-body hypoxia and HT decreased sensitivity of smooth muscles in veins and arteries of GCM and in small intestine veins to isoproterenol, while the combination of both these factors virtually did not affect the dilator reactions of regional vessels to the drug. Since total cooling preceded the hypoxic effects on the organism and hence its vessels, it can be assumed that HT protects organism against hypoxic damage to smooth muscles in regional vessels. Such inference agrees with the results of previous work, in which we studied individual and combined effects of hypoxia and HT on manifestations of constrictor (norepinephrine-induced) reactions of regional veins and arteries by the same method [3]. It also agrees with the data on positive cross-resistance of the organism and its visceral systems to the action of two and more stress factors [4,5].

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