CHANGES IN THE MESENTERIC MICROCIRCULATION OF RATS WITH ACUTE HYPOXIC HYPOXIA

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Hypoxia was induced in rats by administration of a gas mixture corresponding to the composition of the atmosphere at an altitude of 6000 m above sea level. Mesenteric arteries and veins measuring from 9 to 43 μ in diameter were studied. Their diameter and the pressure and velocity of the blood flow in them were measured. The arterial microvessels were dilated in hypoxia. Their diameter was increased by the greatest amount (by 3-5 μ) during the first 3-5 min of administration of the gas mixture. The blood pressure and velocity of blood flow in these vessels were reduced throughout the experiment.
KEY WORDS: *microcirculation; hypoxic hypoxia.*

The problem of the tissue response to hypoxia has not yet been fully explained [1, 2, 4]. In morphological investigations a change in the diameter of the arterioles and capillaries has been observed during hypoxia [6, 7]. However, changes in the microcirculation can be estimated adequately only *in vivo*.

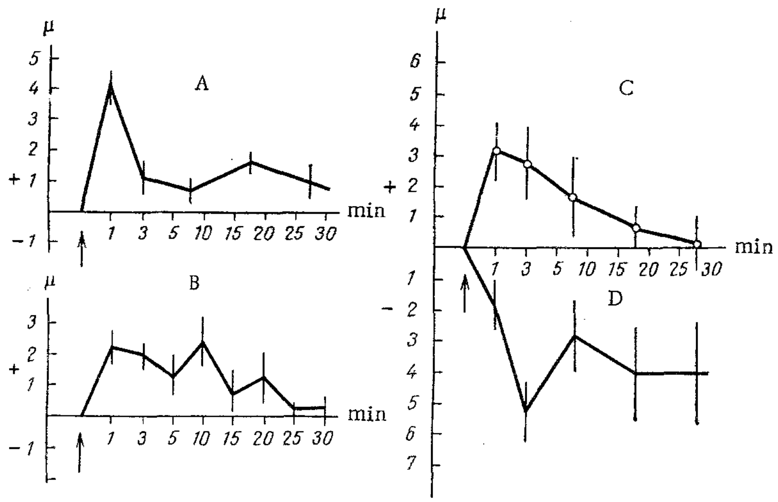

Fig. 1. Effect of acute hypoxic hypoxia on diameter of mesenteric microvessels of albino rats: A) arterial vessels over 20 μ in diameter; B) under 20 μ in diameter; C) venous vessels under 20 μ in diameter; D) over 20 μ in diameter. Here and in Figs. 2 and 3, arrow marks beginning of administration of gas mixture.

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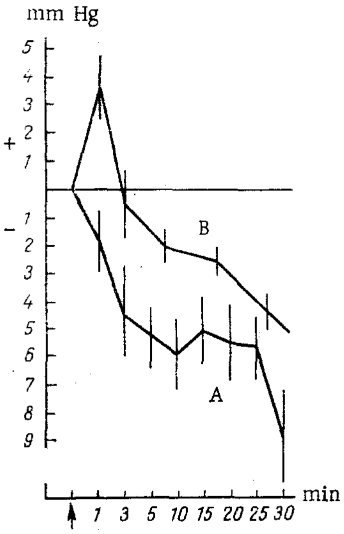

Fig. 2

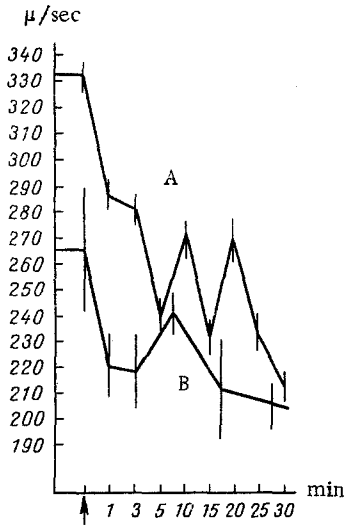

Fig. 3

Fig. 2. Effect of acute hypoxic hypoxia on blood pressure in arterial (A) and venous (B) microvessels of albino rat mesentery.

Fig. 3. Effect of acute hypoxic hypoxia on velocity of blood flow in arterial (A) and venous (B) microvessels of albino rat mesentery.

The diameter of the mesenteric microvessels, the blood pressure, and the linear velocity of the blood flow in them were determined in rats with acute hypoxic hypoxia.

EXPERIMENTAL METHOD

Eighty male albino rats weighing 120-150 g were anesthetized with pentobarbital (4.5 mg/100 g body weight, intraperitoneally). The method used enabled a combined analysis of changes in the microcirculation in the mesentery of warm-blooded animals to be carried out under acute experimental conditions [3, 5]. The basic unit of the apparatus was the Biolam-70 microscope. To study the diameter of the mesenteric microvessels with the aid of the MFN-11 photomicrographic attachment, serial photomicrographs were made on Mikrat-300 film. The linear velocity of the blood flow was measured by means of the ST-5 stroboscopic tachometer. The blood pressure in the microvessels was measured by compressing the vessels until the blood flow in them stopped completely, and then measuring the force required to compress the vessel [3]. The rats inhaled for 30 min a gas mixture corresponding to the composition of the atmosphere at an altitude of 6000 m above sea level. The microcirculation was investigated before and 1 and 3 min after induction of hypoxia, and thereafter at intervals of 5 min throughout the period of hypoxia. Altogether 138 arterial and 87 venous vessels measuring from 9 to 43 μ in diameter were studied. The results were subjected to statistical analysis by the difference method.

EXPERIMENTAL RESULTS AND DISCUSSION

Acute hypoxic hypoxia caused dilatation of the mesenteric arterioles and capillaries. From a mean value in the initial period of 15.0 ± 0.5 μ, by the 10th minute of hypoxia the diameter of the arterial vessels had increased to 17.6 ± 0.8 μ ($P < 0.01$). An increase in the diameter of the larger vessels was observed during the first few minutes of administration of the gas mixture and it was even more pronounced (Fig. 1A, B). The blood pressure in these vessels started to fall by the 3rd minute of hypoxia and by the 10th minute it reached 14.9 ± 1.3 mm Hg (initial pressure 20.8 ± 0.8 mm Hg; $P < 0.001$). By the 30th minute the pressure in the arterioles had fallen to 12.0 ± 1.9 mm Hg. In the interval between the two phases of a fall, the pressure remained relatively constant (Fig. 2A).

The original velocity of the blood flow averaged 331.0 ± 13.5 μ/sec. During the first minutes of hypoxia it fell, to reach 242.5 ± 30.0 μ/sec after 5 min (Fig. 3A). By 30 min, after a period of relative stabilization, the velocity of the blood flow again fell sharply (218.5 ± 15.0 μ/sec, $P < 0.001$).

Venous capillaries under 20 μ in diameter (mean initial diameter 14.7 ± 0.7 μ) were dilated by the end of the first minute of hypoxia (18.0 ± 1.1 μ; $P < 0.01$). Later their diameter gradually returned to normal. Vessels over 20 μ in diameter (mean initial diameter 31.2 ± 1.6 μ), on the other hand, were sharply constricted. By the end of the 3rd minute their diameter was 25.9 ± 1.0 μ ($P < 0.001$). The diameter remained reduced throughout the experiment (Fig. 1C, D). The blood pressure in the venous vessels initially rose from 20.4 ± 0.4 to 24.2 ± 1.3 mm Hg ($P < 0.01$), it returned to its initial level by the 3rd minute, and after 5 min it started to fall gradually, reaching 16.0 ± 0.7 mm Hg by the end of the experiment ($P < 0.001$) (Fig. 2B). The linear velocity of the blood flow in the venous part of the microcirculation fell after the first minute of acute hypoxia. By the end of the experiment it had fallen to 211.0 ± 5.2 μ/sec (initial velocity 266.0 ± 17.2 μ/sec; $P < 0.001$) (Fig. 3B).

The results of these experiments indicate that at the beginning of hypoxia the blood flow in the mesentery increased, as reflected in dilation of the arterioles and capillaries, with a consequent reduction in the blood pressure and in the velocity of the blood flow. An increase in blood flow is evidently the initial response of the tissues to hypoxia and is brought about through activation of local "struggle for oxygen" mechanisms. Later the mesenteric blood flow decreases: The lumen of the vessels starts to contract, and the pressure and the velocity of the blood flow fall still more. This can be explained on the grounds that the local metabolic mechanisms are supplemented by neurogenic and humoral mechanism of regulation of the lumen of the blood vessels, leading to a redistribution of the blood flow to correspond to the metabolic requirements of the various tissues. Constriction of the venules, observed after the first few minutes and persisting throughout the experiment, can be explained by the action of mechanisms aimed at maintaining an effective blood pressure and velocity of the blood flow in the capillaries.

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