EFFECT OF CATECHOLAMINES ON TEMPERATURE, OXYGEN TENSION, AND BLOOD FLOW IN SKELETAL MUSCLES

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Acute experiments on rabbits have shown that injection of adrenalin and noradrenalin (2-200 μg/kg) lowers the temperature and oxygen tension and causes a temporary increase in the blood flow in the gastrocnemius muscle. The author considers that the fall in temperature in the muscle is connected with intensification of endothermic processes.

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The work of N. I. Putilin and collaborators has shown that when an organ changes from one functional state into another, regular periodic fluctuations of temperature are observed and, to some extent, these may serve as a pressure of the intensity and direction of metabolic processes [3, 8].

Adrenalin and noradrenalin are known to have a marked effect on changes in metabolism in different organs and tissues [5, 9].

Accordingly, in the present investigation the temperature, oxygen tension (pO_2) and blood flow were studied in a skeletal muscle following intravenous injection of these substances.

EXPERIMENTAL METHOD

Acute experiments were performed on rabbits. The temperature, pO_2, and blood flow were measured in the gastrocnemius muscle by the methods used in our previous investigations [2]. The temperature was measured by a copper-constantan thermocouple, the velocity of the blood flow by Hensel's thermoprobe, and pO_2 by a polarographic method. The detectors were connected to mirror galvanometers, and the deflections of the beams of light were recorded on the paper of a photokymograph. After the changes in these indices of the rabbit had been recorded in a state of physiological rest, adrenalin or noradrenalin was injected intravenously in doses of 2, 10, or 200 μg/kg body weight, made up in 1 ml physiological saline at a temperature of 38°.

EXPERIMENTAL RESULTS

Intravenous injection of 1 ml physiological saline caused no changes in the temperature, pO_2, and blood flow in the muscle.

Injection of adrenalin in a dose of 2 μg/kg led to a decrease in temperature by 0.21±0.02° and pO_2 by 27±2.83% ($P < 0.001$), while the blood flow diminished after a brief increase (Fig. 1A). Injection of larger doses of adrenalin (10 μg/kg) was accompanied by a decrease of temperature by 0.48±0.0033° ($P < 0.001$), and of pO_2 by 60±2.5% ($P < 0.001$), while the blood flow increased after a decrease lasting for 1 min. This increase continued for between 2 and 15 min, and was followed by a prolonged decrease of the blood flow in the muscle (Fig. 1B). More marked changes of temperature, pO_2, and blood flow in the muscle were observed after injection of adrenalin in a dose of 200 μg/kg. This dose lowered the temperature by 1.5±0.08° ($P < 0.001$) and the pO_2 by 80±4.35% ($P < 0.001$). The increase of blood flow continued longer in this group of experiments than in those mentioned above, but after 30-40 min the blood flow in the muscle fell below its initial level. This decrease persisted throughout the period of observation (Fig. 1C).

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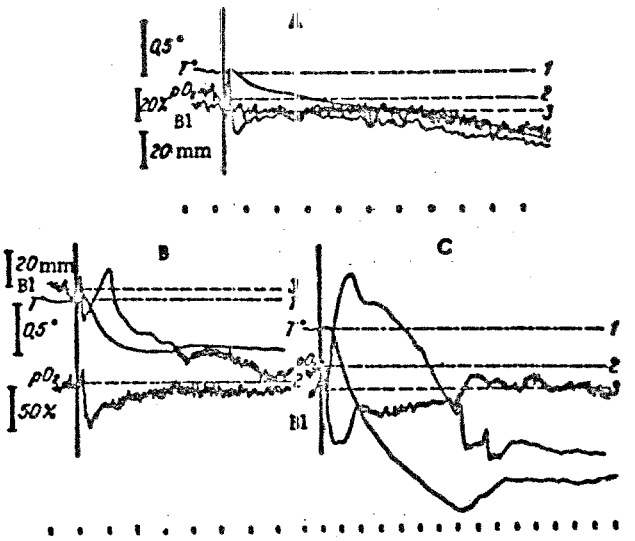

Fig. 1. Changes in temperature (T), oxygen tension (pO_2), and blood flow (Bl) in the gastrocnemius muscle of a rabbit after intravenous injection of adrenalin in doses of: 2 μg/kg (A), 10 μg/kg (B), and 200 μg/kg (C). Vertical line represents moment of injection of drug, horizontal line represents initial level of temperature (1), pO_2 (2), and blood flow (3). Calibration scales: temperature 0.5, pO_2 50%, blood flow 20 mm (in millimeters of galvanometer scale). Below – time marker (5 min).

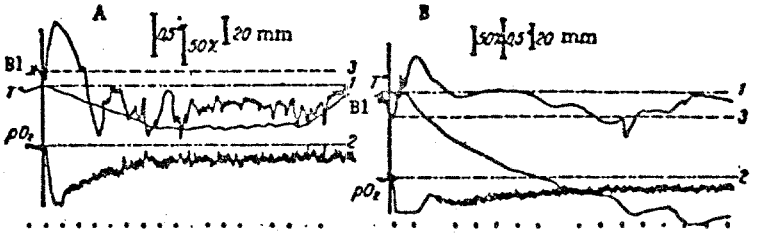

Fig. 2. Changes in temperature, oxygen tension, and blood flow in gastrocnemius muscle of rabbit after intravenous injection of adrenalin (A) and noradrenaline (B) in a dose of 200 μg/kg body weight. Legend as in Fig. 1.

Similar changes in temperature, pO_2, and blood flow in the muscle were observed after intravenous injection of noradrenalin in a dose of 200 μg/kg (Fig. 2B). The muscle temperature in these experiments fell by 0.41±0.035°, and pO_2 fell by 86±0.22% ($P < 0.001$). As the results given in Fig. 2A show, adrenation in a dose of 200 μg/kg caused a greater decrease in muscle temperature (by 1.09±0.087°) than noradrenalin ($P < 0.001$). So far as pO_2 is concerned, the difference was only 6% ($P < 0.05$). The changes in blood flow occurred in two phases: an increase was observed after injection, to be followed by a decrease below the initial level (Fig. 2B).

The decrease in pO_2 in the rabbit's muscle after intravenous injection of adrenalin or noradrenalin may be explained by stimulation of oxidative processes in the muscle. This is the more probable because the decrease in pO_2 took place in association with an increase in blood flow.

The decrease in muscle temperature after injection of adrenalin and noradrenalin cannot be attributed to changes in blood flow, because the latter increased for some time after injection of the drugs, during

which time the temperature must have been raised. The decrease in temperature likewise cannot be attributed to an increase in the output of heat through the skin, because adrenalin constricts its vessels. The work of some authors has shown that the heat production of a muscle diminishes during stimulation of the sympathetic nerve, evidently on account of a more economic utilization of energy [9]. After intravenous injection of adrenalin the temperature also falls in the heart muscle [1].

It may be postulated on the basis of these results that in the intact organism adrenalin and noradrenalin stimulate endothermic processes in skeletal muscle.

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