REACTIONS TO PROLONGED ARTIFICIAL CIRCULATION

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In conditions of a natural circulation, an important role in regulation of certain physiological functions (the level of oxidative processes, redistribution of blood, dissociation of oxyhemoglobin, etc.), of great importance for maintaining the vital activities of the organism, is played by the CO_2 of the blood, as many physiological investigations have shown [1-4, 6-11, 12].

However, only isolated references can be found in the literature to the role of CO_2 in the conditions of artificial circulation [5].

The object of the present investigation was to study reactions of the organism to CO_2 during prolonged artificial circulation.

EXPERIMENTAL METHOD

Experiments were carried out on 29 adult dogs anesthetized with ether and oxygen with an intraesophageal temperature of 36-24.6°. The artificial circulation was maintained by a Crafoord-Soenning apparatus. The apparatus was connected by separate cannulas to the superior and inferior venae cavae and to the femoral artery. The volume velocity of perfusion varied between 70 and 100 ml/kg body weight. Depending on the output of the apparatus, O_2 was supplied into the oxygenator at the rate of 10-15 liters/min and CO_2 at the rate of 3, 4, 6, and 10%.

The effect of CO_2 introduced into the oxygenator (oxygen-carbon dioxide administration) was investigated for 10-20 min, when the supply of CO_2 into the oxygenator was shut off for the same length of time and only O_2 supplied (oxygen administration). During the experiment the two types of gas administration were alternated several times.

When different gas mixtures were present in the oxygenator, the content of O_2 and CO_2 in the arterial and venous blood were investigated by Van Slyke's method, the blood oxygen saturation was determined with a cuvette oxymeter, the volume velocity of the cerebral circulation was determined by a volumetric method, P_{CO_2} was measured with an Astrup's apparatus, and the vascular tone, arterial pressure, and ECG were recorded. The oxygen consumption was calculated. The tone of the hind limb vessels was investigated (resistography) in 10 experiments using the autoperfusion principle with a constant volume velocity, and taking blood from the oxygenator maintaining the general artificial circulation.

EXPERIMENTAL RESULTS

The investigations revealed regular reactions of the animals both to administration of CO_2 and to discontinuation of its supply into the oxygenator. The mean values of the volume velocity of the cerebral blood flow and O_2 consumption of the brain are given in Fig. 1. These mean values were calculated from the results of 16 of the 19 experiments carried out in identical temperature conditions (intraesophageal temperature 27-29°).

It is clear from Fig. 1 that addition of CO_2 to the O_2 supplied into the oxygenator caused an increase of the cerebral blood flow and oxygen consumption of the brain. After the supply of CO_2 into the oxygenator ceased the cerebral blood flow and oxygen consumption of the brain fell. These changes were regularly

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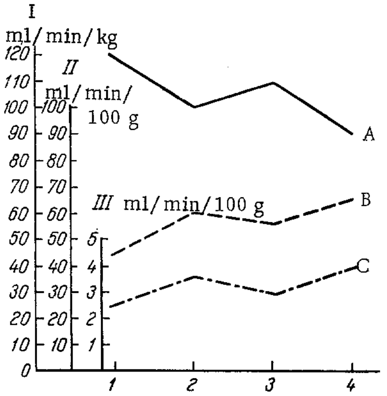

Fig. 1. Changes in volume velocity of perfusion (I), cerebral blood flow (II), and oxygen consumption of the brain (III) depending on composition of gas in oxygenator. 1, 3) O_2, 2, 4) $O_2 + CO_2$. A) Volume velocity of perfusion; B) volume velocity of cerebral blood flow; C) oxygen consumption of the brain.

observed also in experiments when the intraesophageal temperature of the animals fluctuated between 35-31° and 26-25°.

The increase in volume velocity of the cerebral blood flow and oxygen consumption of the brain observed with a change to administration of oxygen and carbon dioxide was not counted with changes in the volume velocity of perfusion, for it was observed in experiments in which the output of the apparatus remained constant throughout (38% of cases) and also when the output was diminished (57% of cases) or increased (5% of cases) after the addition of CO_2 into the oxygenator.

These reactions—changes in the cerebral blood flow and oxygen consumption of the brain—likewise were not connected with fluctuation in the arterial pressure. The pressure rose and fell by 10-20 mm.

The heart rate in most cases became slightly slower after a change to administration of oxygen and carbon dioxide, but in some cases it remained unchanged or even rose very slightly. Because of the absence of consistent changes in arterial pressure and heart rate following a change from oxygen to oxygen-carbon dioxide administration, it may be assumed that the increase in the cerebral blood flow observed in these experiments was associated with the effect of CO_2 on the tone of the blood vessels.

With a change from oxygen to oxygen-carbon dioxide administration, together with dilatation of the blood vessels of the brain (as shown by the increase in cerebral blood flow), constriction of the blood vessels was observed in the skeletal muscles. This was confirmed by the results of resistography. As a rule, after administration of CO_2 into the oxygenator in doses of 3, 4, 6, and 10%, the tone of the blood vessels in the hind limbs increased, falling to its original level after the administration of CO_2 was stopped. These reactions were manifested immediately after the beginning or end of the supply of CO_2 into the oxygenator (Fig. 2).

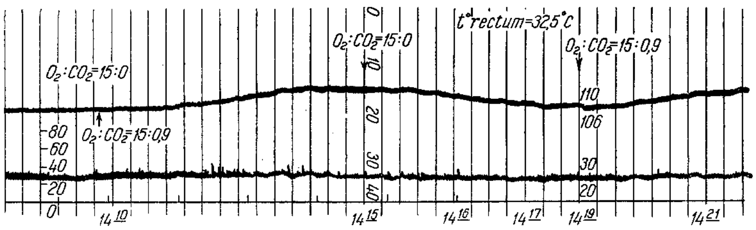

Fig. 2. Changes in vascular tone in the hind limb of a dog with different gas mixtures in the oxygenator. From top to bottom: resistogram of dog's hind limb vessels; systemic arterial pressure; zero line with time marker on it.

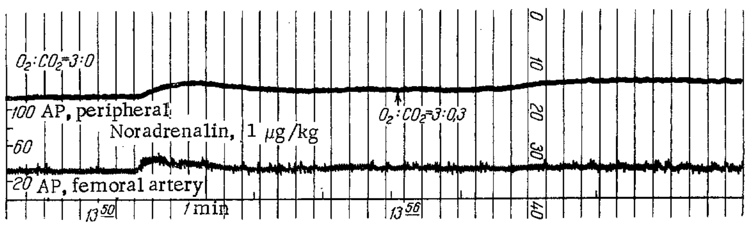

Fig. 3. Changes in vascular tone in the hind limb of a dog following intravenous injection of noradrenalin and with different gas mixtures in the oxygenator. Legend as in Fig. 2.

Changes in the vascular tone under the influence of CO_2 appeared both when the general blood pressure level fluctuated and when it remained constant.

The changes in vascular tone described above, observed on the administration of CO_2 into the oxygenator or on its discontinuation, occurred in different functional states of the vascular system and against the background of the action of other substances influencing vascular tone. The increase of tone of the vessels after injection of noradrenalin into the blood stream in a dose of 1 μg during perfusion with administration of oxygen alone is shown in Fig. 3. It is clear from this figure that against this background of increased vascular tone produced by noradrenalin, administration of 10% CO_2 into the oxygenator led to a further increase in vascular tone in the hind limb.

These reactions to CO_2 (changes in velocity of the cerebral blood flow and oxygen consumption of the brain, and also changes in vascular tone) were observed during experiments lasting 1 and 2 h in artificial circulation conditions. Administration of CO_2 into the oxygenator in these experiments facilitated manifestation of the action of the mechanisms responsible for redistribution of blood to provide a better blood supply to the vitally important organs and to cater for their O_2 requirements.

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