

PHYSIOLOGY

THE BLOOD SUPPLY OF THE BRAIN DURING REFLEX REACTIONS

Second Report

THE BLOOD SUPPLY OF THE BRAIN DURING INTEROCEPTIVE IRRITATION OF THE SMALL INTESTINE IN THE PRESENCE OF HYPERCAPNIA

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In the preceding report it was shown that with irritation of the interoceptors of the small intestine in some cases there occurs an increase, and in others a decrease, in the blood supply of the brain. On the basis of an analysis of synchronous changes in the volumetric rate of blood flow and in arterial pressure, the supposition was advanced that the nature of the reaction of the vessels of the brain during interoceptive irritation on the whole depends on the initial tonus of these vessels prior to irritation. For the purpose of verifying experimentally this hypothesis in the present work research was done on the blood supply of the brain during interoceptive irritation in the presence of hypercapnia.

As the data in the literature affirm, the pressure of CO_2 in the blood exerts a considerable influence on the state of tonus of the brain vessels. In a single experiment the pressure of CO_2 in the blood of different animals may vary considerably, depending upon the extent of narcosis, operative procedures and the character of respiration.

It has been established by a series of examinations (for a survey of the literature see the article by Bouckaert and Jordan [5]) that, when the pressure of CO_2 in the blood is increased, as a result of the direct, peripheral effect of CO_2 on the vessel walls there occurs dilation of the vessels and an increase in the supply of blood to the brain, while, when the pressure of CO_2 in the blood falls off, there occurs a constriction of the vessels and a decrease in the brain's blood supply. In contrast to other vascular regions a central vasoconstricting effect of CO_2 is not manifested on the vessels of the brain.

The threshold of the dilating effect of CO_2 for the vessels of the brain proved to be very low. These vessels are dilated at that level of CO_2 in the inspired air at which neither the respiratory nor the vasomotor center reacts [6, 9, 10 et al].

Some research was devoted to a study of arterial pressure reactions during interoceptive irritation in the presence of short-term hypercapnia. E. Sh. Airapetyants [1], V. N. Zvorykin [2] and T. V. Popova [4] observed during weak hypercapnia (5-7% CO_2 in the mixture) an intensification of the reaction only in those cases in which there was a distinct reaction of respiration and blood pressure in response to inspiration of mixtures containing CO_2 . Strong hypercapnia (10% and higher) is accompanied by a two-phase change in the arterial pressure reaction during irritation of the interoceptors: in the initial stages an increase was observed and in the subsequent stages a depression or distortion of the reaction. There is no data in the literature on the change in the blood

supply of the brain during interoceptive irritation in the presence of hypercapnia.

EXPERIMENTAL METHODS

Experiments were conducted on 19 adult dogs under morphine-urethane narcosis.

In accordance with our project we employed low concentrations of CO_2 in the inspired air, under the influence of which there appeared a distinct increase in the blood supply of the brain and negligible changes in respiration and arterial pressure. For inspiration of the mixtures Douglas bags were used with respiratory valves in a T-pipe inserted in the trachea. Inhalation of the mixture continued for 10-15 minutes.

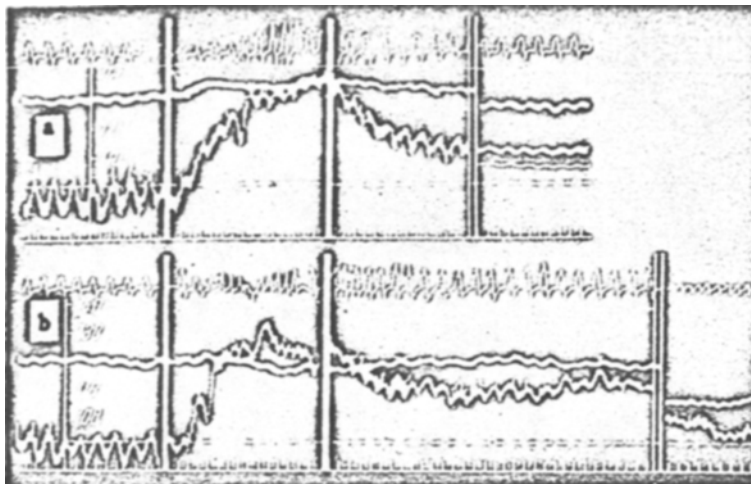


Fig. 1. Photokymogram of the experiment of September 17, 1954.

a) Reaction to irritation of the interoceptors during breathing of the air of the room; b) reaction to irritation of the interoceptors 14 minutes after cessation of inhalation of a mixture containing 7.1% CO_2 . From above down: respiratory movements, volumetric rate of blood flow in the meninges, arterial pressure, time scale. Vertical lines: the beginning and end of irritation. Double vertical lines: interruption of recording. Broken lines: level of the characteristics being recorded prior to the beginning of irritation.

Irritation of the interoceptors was effected by inflating a section of the small intestine with air under a pressure of 80 mm of mercury. This stimulation was performed 2-3 times until a stable reaction was obtained while the animal breathed the air of the room, once during inhalation of the CO_2 mixture and several times in the course of 1-2 hours after the animal reverted back to breathing the air of the room. The intervals between irritations amounted to not less than 15 minutes. In order to judge the blood supply of the brain we recorded the volumetric rate of blood flow in the meninges by the thermoelectric method using a flat thermoelectrode.

The arterial pressure in the femoral artery was recorded with a mercury manometer and respiratory movements with a pneumograph. All the indicated characteristics were recorded synchronously on a photokymograph.

EXPERIMENTAL RESULTS

During inhalation of the mixtures of air containing 4.5-7.5% CO_2 there was observed a small increase in the amplitude, an alternating increase and decrease in the frequency of respiratory movements and negligible changes in the level of the arterial pressure, which increased as well as decreased within the limits of 5 to 8 mm on a mercury column. At the same time the blood supply of the brain increased after 4-8 seconds and