THE CIRCULATION IN DIFFERENT PARTS OF THE CEREBRAL CORTEX DURING PHOTIC AND OLFACTORY STIMULATION

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Although the subject of the local changes in the velocity of the blood flow in the cerebral cortex during the action of adequate stimuli is of great theoretical and practical importance, few attempts have so far been made to study it. It has been shown that during photic, olfactory, acoustic, and tactile stimulation a selective increase takes place in the blood flow in the corresponding parts of the cortex [1, 3-5, 8, 9]. However, the methods so far used either gave no opportunity for studying the dynamics of the blood flow into the brain [3, 9], or they did not rule out the possibility that the results obtained may have been dependent on changes in brain metabolism [1, 4, 5, 8, 9]. Furthermore, in most cases the experiments were conducted on anesthetized animals, which causes profound changes in the reactivity of the central nervous system.

The object of the present investigation was to study the dynamics of the blood supply to different parts of the cerebral cortex during the action of adequate stimuli (photic and olfactory) on unanesthetized animals.

EXPERIMENTAL METHOD

Experiments were carried out on 15 unanesthetized rabbits. The velocity of the blood flow was recorded by means of the thermoelectric needles suggested by M. E. Marshak [2], yielding results which are unaffected by variations in temperature caused by metabolic changes. The thermoelectrodes were fixed into the holders of a stereotaxic apparatus and inserted into the cerebral cortex to a depth of 1 mm in symmetrically opposite areas. Changes in the velocity of the blood flow were also recorded in the occipital and parietal regions and in the olfactory bulbs. Simultaneous recordings were made of the arterial pressure and respiration. All the curves were traced by means of a photokymograph. Interrupted photic stimulation was applied by means of a 100 W incandescent lamp for a period of 1-4 min. A weak solution of tincture of ammonia was used as olfactory stimulus.

EXPERIMENTAL RESULTS

Photic stimulation led to a selective increase in the velocity of the blood flow in the occipital region (Fig. 1). Since the arterial pressure remained unchanged under these circumstances it may be concluded that the increase in the velocity of the blood flow was the result of active vasodilatation. The velocity of the blood flow in the other regions of the cortex in most cases was unchanged. The blood flow in the parietal region sometimes showed a slight increase, but it was much less marked and later to appear than in the occipital region. The changes in the blood flow in the occipital region followed a varied course. In some cases (Fig. 1 A) the latent period was short (2-4 sec). The velocity of the blood flow increased only during the first 10-30 sec after the beginning of stimulation and remained above the initial level throughout the period of stimulation. After cessation of stimulation a rapid return took place to the original level.

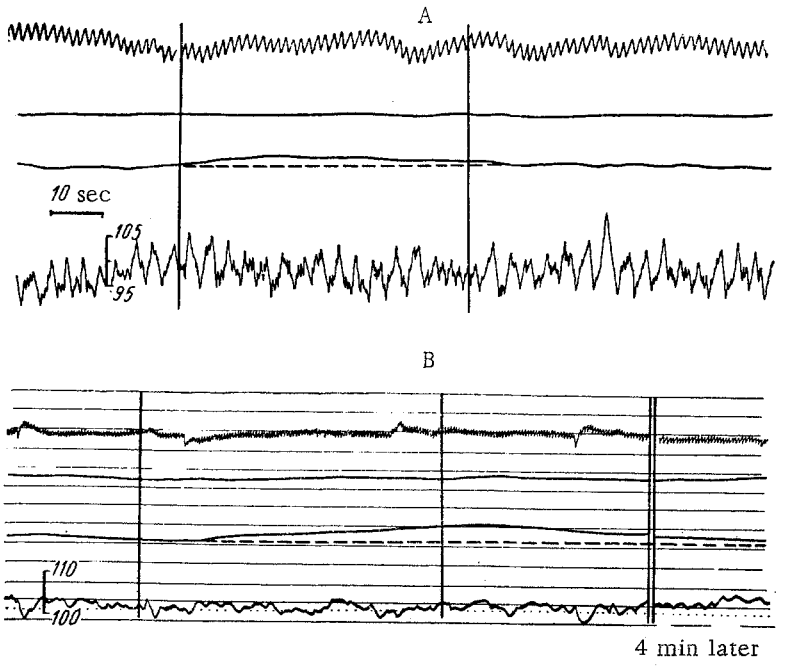

Fig. 1. Effect of photic stimulation on velocity of blood flow in various parts of the brain. A) A case with a short latent period; B) with a longer latent period. Significance of curves (from above down): respiration, velocity of blood flow in olfactory region, velocity of blood flow in occipital region, arterial pressure. Time marker 5 sec. In all figures the vertical lines denote the beginning and end of stimulation. The broken line denotes the initial level of the blood flow.

In other cases (Fig. 1B) the latent period was longer, sometimes reaching 20-25 sec. The increase in the blood flow developed gradually. The maximum increase in blood flow was observed at the end of stimulation. After cessation of stimulation the velocity of the blood flow also returned gradually to its original level (over a period of a few minutes). The degree of the increase in blood flow and the duration of the after-effect depended in these cases on the duration of stimulation. No sharp line could be drawn between the two types of reaction: intermediate forms were also observed. So far as the reasons for these differences are concerned, it can only be assumed that they were due to differences in the functional state of the animal during the investigation or to individual differences between the animals.

Olfactory stimulation caused a selective increase in the blood flow in the olfactory bulbs (Fig. 2). In response to weak stimuli the blood flow in other regions remained unchanged (Fig. 2A). With stronger stimuli a slight increase or decrease in the velocity of the blood flow took place in the parietal and occipital regions, and often the reaction was biphasic in character (Fig. 2B). A decrease in the velocity of the blood flow in the parietal region was observed more frequently and was more marked in degree than in the occipital region. It coincided in time with a sharp increase in the blood flow in the olfactory region. As Fig. 2 shows, the arterial pressure in these cases did not increase. Consequently, the increase in blood flow in the olfactory bulbs was caused by active vasodilatation.

With even stronger stimuli a generalized motor reaction took place, accompanied by elevation of the arterial pressure. The blood flow in these circumstances was increased in all parts of the cortex (Fig. 3). However, this increase in these cases too was more marked, developed sooner, and lasted longer in the olfactory zone than in the other zones of the cortex. Whereas the increase in the blood flow in the olfactory region developed immediately after application of the stimulus, the blood flow in the parietal and occipital regions at first diminished, and began to rise only after a short time. After cessation of stimulation the blood flow in the olfactory region remained elevated for a long time, while the blood flow in the parietal and occipital regions fell below its initial level. Since the arterial pressure was usually above the original level at this time, it may be concluded that an increase in the vascular tone had taken place in the parietal and occipital regions.

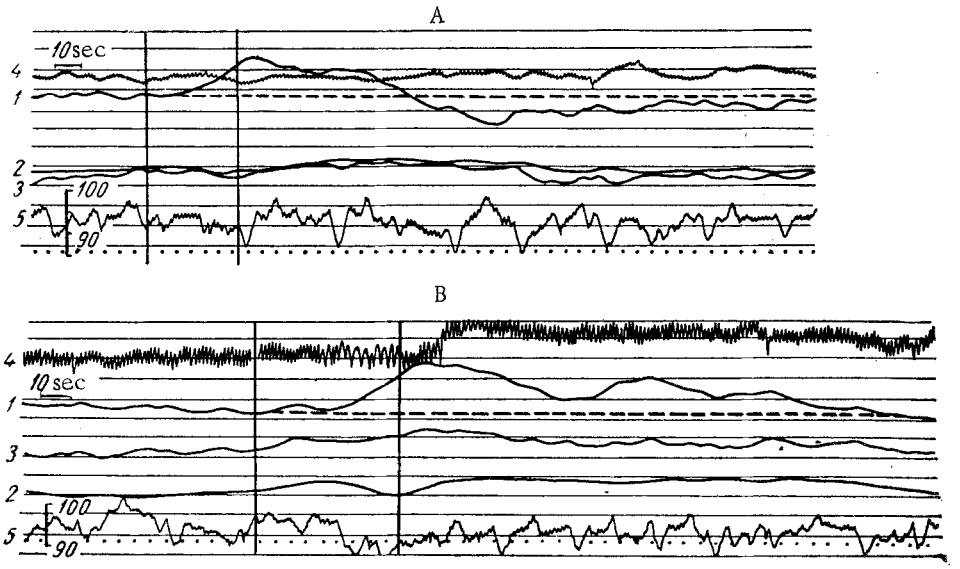

Fig. 2. Effect of olfactory stimulation on velocity of blood flow in different parts of the brain. A) Weak stimulation; B) stimulation of moderate intensity; 1) velocity of blood flow in olfactory region; 2) in parietal region; 3) in occipital region; 4) respiration; 5) arterial pressure. Time marker 5 sec.

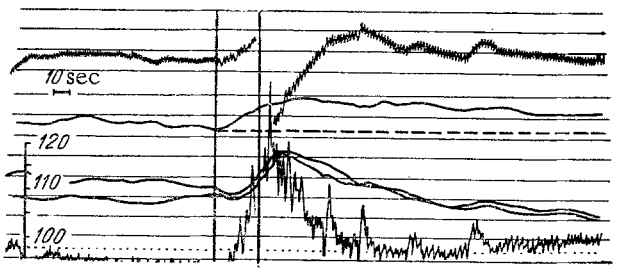

Fig. 3. Changes in velocity of blood flow in different areas of the brain in response to strong olfactory stimulation. Significance of curves (from top to bottom): respiration, velocity of blood flow in olfactory region, velocity of blood flow in parietal region, velocity of blood flow in occipital region, arterial pressure. Time marker 5 sec.

Hence, the increase in the functional activity of a particular area of the cerebral cortex is accompanied by an increase in the blood supply to that area. At the same time, the blood supply to other areas either is unchanged or it varies only slightly, depending on the strength and duration of the stimulation. Either an increase or a decrease in the blood flow is possible in other areas. A "mosaic" of changes in the velocity of the blood flow is observed in different cortical zones, evidently corresponding to he mosaic of excitation in the cortex. Meyer and coworkers [6, 7], who investigated the oxygen and carbon dioxide tension in brain tissues, concluded that during photic stimulation a selective increase takes place in the metabolism in the occipital region of the cortex. In the light of these findings, it may be postulated that the increase in the blood supply of the active areas of the brain was caused by the increased metabolism in these areas.

SUMMARY

A study was made of changes occurring in the local blood circulation in the parietal, occipital and olfactory areas of the cerebral cortex during light and olfactory stimulation. Experiments were conducted on nonanesthetized rabbits. Circulation rate was determined by the thermoelectric method. Light stimuli produced a selective intensification of the blood flow in the occipital area, olfactory stimulation -in the olfactory bulbs. Circulation was enhanced even when the general arterial pressure remained unchanged. The blood flow in other cortical areas of the brain remained unchanged or changed less significantly than in the active cortical portions. It is suggested that an increased blood supply of the active brain areas is due to the intensified metabolism in them.

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