CONFLICTING CHANGES IN THE ZONAL CIRCULATION IN THE CEREBRAL CORTEX DURING ITS FOCAL EXCITATION

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The blood flow in the visual, auditory, and somatosensory areas of the cortex was recorded by a thermoelectric method in cats and rabbits anesthetized with urethane. After application of 0.1% strychnine solution to the visual cortex, excitation and a corresponding increase in the blood flow in this zone were accompanied by a decrease in the blood flow in the auditory cortex. After application of strychnine to the auditory cortex, the blood flow was reduced in the visual cortex. After application of strychnine to the somatosensory cortex, the blood flow was reduced in the auditory cortex.

A previous investigation [6] showed that in the waking animal an increase in the blood flow in the visual cortex evoked by photic stimulation (flashes) is accompanied in most cases by a decrease in the blood flow in the auditory cortex. To continue the study of the mechanism of the conflicting responses of cortical blood vessels it was decided to determine whether these changes in blood flow are characteristic of particular cortical areas and to identify the factors which could be responsible for the decrease in cerebral blood flow in a zone bordering on an excited area. Strychnine application was used as the stimulus producing local intensification of cortical unit activity.

EXPERIMENTAL METHOD

Experiments were carried out on 24 cats and 6 rabbits anesthetized with urethane (1 g/kg body weight). Changes in the cerebral zonal circulation were recorded in the visual, auditory, and somatosensory cortex by modified flat [4] and needle thermoelectrodes. The arterial pressure in the femoral artery was recorded at the same time. A local focus of excitation in the cortex was induced by application of 0.1% strychnine solution by means of filter paper measuring 2 × 5 mm, placed 2-2.5 mm from the thermoelectrode.

EXPERIMENTAL RESULTS AND DISCUSSION

Application of strychnine to the visual cortex evoked a definite increase in the blood flow in this area. Usually the increase in blood flow began after 5-15 sec and reached a maximum after 30-40 sec (Fig. 1A). After removal of the filter paper and rinsing with physiological saline the blood flow still remained high for 5-12 min, after which it returned to its initial level. These changes in the blood flow in the excited area were not accompanied by any change in the arterial pressure. Similar changes were observed when the cerebral blood flow was recorded in a focus of increased activity evoked by strychnine [5, 9]. Simultaneous recording of changes in the blood flow in two cortical projection areas showed that excitation and the corresponding increase in blood flow in the visual cortex were accompanied by a marked decrease in the blood flow in the auditory cortex.

In most experiments this decrease in the blood flow in the other cortical projection area occurred 2-5 sec after the response of the vessels in the excited area (compare Fig. 1A and B). It is important to note that these opposite changes in the zonal blood flow also developed after application of strychnine to the auditory cortex. In that case (Fig. 1B), the increase in blood flow in the auditory cortex was accompanied

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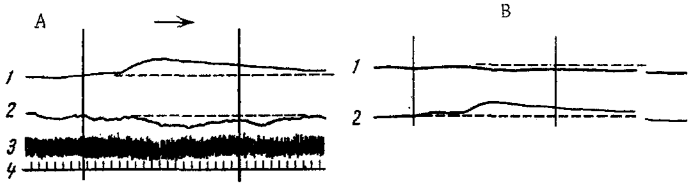

Fig. 1. Opposite changes in blood flow in visual and auditory areas of the cortex after application of strychnine to the visual (A) and auditory (B) cortex: 1) blood flow in visual cortex; 2) blood flow in auditory cortex; 3) arterial pressure; 4) time marker 5 sec.

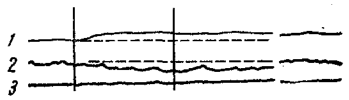

Fig. 2. Increase in blood flow in somatosensory cortex and decrease in auditory cortex after application of strychnine to somatosensory cortex: 1) blood flow in somatosensory area; 2) blood flow in auditory area; 3) blood flow in visual area of the cortex.

by a decrease in the blood flow in the visual cortex. The opposite responses described above were observed in experiments on both cats and rabbits. By evoking a local response of excitation in the visual or auditory cortex by means of strychnine, changes in blood flow analogous to those obtained in response to sensory stimulation in the waking animal [6] were thus reproduced. Coupled but opposite responses in the brain are not a characteristic feature of increased activity of a single projection zone only. Opposite responses of the cerebral blood flow of a similar type have also been observed in man by the use of different techniques [10]. Mental activity in man has been shown to be accompanied by a local increase in the blood flow in some areas of the cortex and by a decrease in others.

This type of redistribution of blood in the brain can be attributed to a hemodynamic mechanism: dilatation of the cerebral vessels in the excited area of the cortex results in a decrease in the blood flow in the neighboring zone. In the experiments described above, when the blood flow was recorded simultaneously in three cortical projection areas (visual, auditory, somatosensory) after application of strychnine to the somatosensory cortex the increase in blood flow in this region was accompanied by a decrease in the auditory (Fig. 2). Under these circumstances the blood flow in the visual cortex was unchanged. In these experiments also, opposite changes in blood flow were observed in neighboring areas (somatosensory and auditory). No vascular changes were observed in areas of the cortex remote from the active zone.

The results of these experiments indicate that a hemodynamic factor may be concerned in the onset of these reciprocal changes in the blood flow in the cortex. However, this alone could hardly explain the opposite changes in the cortical circulation. On the basis of observations indicating the presence of wide bilateral transcortical connections [7], these reciprocal changes in the blood flow can be regarded as reflecting functional relationships between different cortical projection areas.

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