REGULATION OF THE CEREBRAL CIRCULATION IN KITTENS

N. N. Benua and G. P. Lesnyak

UDC 612.824-019:612.65

Adequate stimulation of the eyes in kittens causes less constant or marked dilatation of the blood vessels of the occipital lobe than in adult cats. The blood flow through the visual cortex in kittens also increases during adequate stimulation of the auditory analyzer.

* * *

The object of this investigation was to determine certain peculiarities of regulation of the cerebral circulation in cats at early stages of ontogenesis.

EXPERIMENTAL METHOD

Experiments were performed in a darkened room on 18 kittens aged from 2 to 4 weeks, anesthetized with urethane. Photic stimuli were applied from ordinary 25 and 100 W incandescent lamps. The source of light was placed 80 cm away from the animal's eyes. The acoustic stimulus was a buzzer. To abolish the pupillary reaction, atropine was instilled into both eyes. The blood flow through the visual cortex (middle portion of the lateral gyrus) was recorded by two electrodes implanted into the brain in this region to a depth of 2-3 mm, and at a distance of about 8-10 mm apart. The electrodes–brain system formed one arm of a bridge circuit, which was balanced with respect to resistance and capacitance by a supply field with frequency 20 kc and voltage 0.8 V. Changes in resistance indicated changes in blood flow through the studied regions relative to a conventional zero level.

EXPERIMENTAL RESULTS AND DISCUSSION

On the electroplethysmogram (EPG) of part of the occipital cortex of an anesthetized kitten (Fig. 1) waves synchronized with the pulse and respiration (c) could be seen, together with slower waves. The latter were very inconstant in character as regards both amplitude and duration, and only in a few experiments (or parts of one experiment) did they resemble waves of the third order.

The mean amplitude of the EPG pulse waves of the kitten was 0.3 Ω, compared with a mean total resistance of the part of the brain between the two electrodes of 1000 Ω, i.e., 0.3%, while the mean amplitude of the respiratory waves was 0.2 Ω, or 0.02%. The amplitudes of the aperiodic EPG waves lay within the range 0.5-5 Ω, or 0.05-0.5%.

The local EPG of the visual cortex is characterized by inconstancy of the basic level (the background) of the blood volume. The curve usually remained at the same level for not more than 2-3 min, after which it shifted in one direction or the other by a small amount. This did not prevent demonstration of a local response to the stimulus, which was fairly constant in magnitude and of the order of 1 Ω. In these experiments, as a result of displacement of the EPG and the action of the stimulus, often the curve did not return to its initial level (as is found as a rule with adult animals), but remained indefinitely at the new level (Fig. 1b). In some tests a response to stimulation appeared after a very long latent period (10-20 sec or more) or even after the light had been turned off. The number of positive responses to the photic stimulus in the kittens was 40-50% of the total number of tests with light. Hence, there is a definite relationship between the volume of blood in the visual cortex and the state of the peripheral receptor in kittens, although it is not so constant and precise in character as in adult animals.

I. I. Mechnikov Leningrad San.-Hyg. Medical Institute and Central Research Laboratory, Leningrad
(Presented by Active Member of the Academy of Medical Sciences of the USSR D. A. Biryukov). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 65, No. 5, pp. 18-21, May, 1968. Original article submitted September 26, 1966.

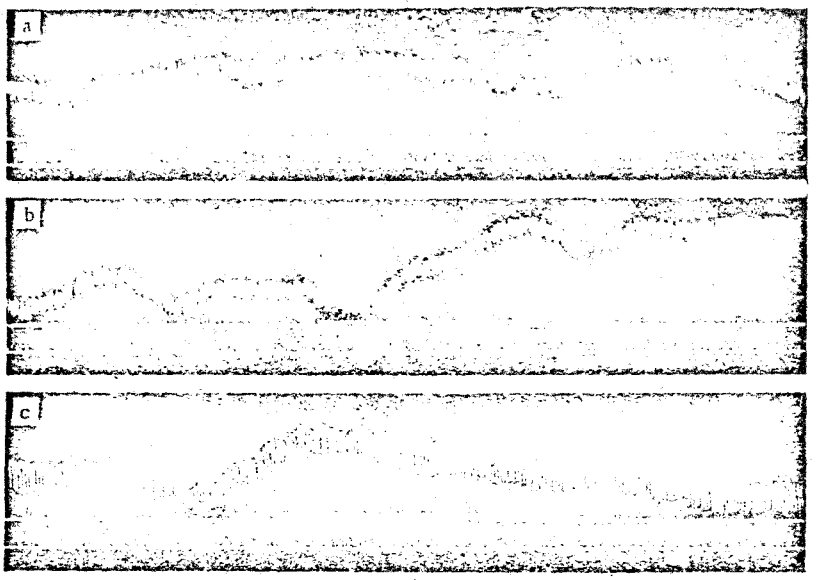

Fig. 1. Background EPG of right occipital cortex of a cat (a) and EPG during and after photic stimulation against a background of movement (b) or rest (c). From top to bottom: EPG, marker of stimulation, time marker (in sec).

Fig. 2. EPG of right occipital region of a kitten during acoustic (a) and photic (b) stimulation. Latent periods are different. Legend as in Fig. 1.

No strength relationships were found in the retina–visual cortex–supply apparatus system in the kitten. In adult animals in some experiments a definite correlation was observed between the intensity of stimulation and the response of the local blood flow in a particular part of the brain.

A special feature of the local regulation of the cerebral blood flow in kittens is the complete absence of differential response of the local blood flow to stimulation of a particular modality, as is clearly found in adult animals. The vessels of the visual cortex, reacting to illumination of the eyes by a marked increase in the volume of blood they contained, in most cases also responded well to acoustic stimulation. However, in the latter case the latent period of the response was frequently longer than during photic stimulation (Fig. 2). Irregular fluctuations in the EPG level could not be attributed to any one factor. Data in the literature on this matter are contradictory [2, 3]. It follows from these characteristics of the EPG reflecting blood flow in the occipital cortex of the kittens that the whole complex of vessels in this part of the brain evidently does not always function as a single entity. Slow, regular waves, indicating synchronized changes in vascular tone in this region, appear only from time to time. The cause of these waves was not established. It may perhaps be the spontaneous rhythmic activity of the smooth-muscle wall of the blood vessels [4]. If this is so, the fact that these background waves are present mainly in animals at the early stages of ontogenesis may be explained by imperfection of the regulatory mechanisms in young animals.

Whereas in experiments on adult animals, changes in blood flow of different intensity are found in response to application of photic stimuli of different strengths, no such result was observed in any of the experiments on kittens. In conjunction with the very wide variability of changes in blood flow in response to application of stimuli of the same strength, this fact suggests that the mechanisms adapting the local circulation to local changes in functional activity of the nerve cells are still imperfect at the early stages of

postnatal development, compared with their state in adult animals. Further evidence of this imperfection was given by the absence of a differential response of the blood vessels of the visual cortex in the young animals to two stimuli of different modalities (acoustic, photic).

Under our experimental conditions (immaturity of systems regulating the blood supply to this particular part of the brain compared with those in adult animals) the system responsible for precise adaptation of the blood flow by redistribution of blood predominantly to cells activated at a given moment functions imperfectly.

LITERATURE CITED

1. T. P. Zhukova, Pediatriya, No. 1, 35 (1953).
2. N. N. Studenikina, in: Proceedings of the Second Volga Conference of Physiologists, Biochemists, and Pharmacologists [in Russian], Kazan' (1961), p. 463.
3. M. A. Ukolova and Yu. N. Bordyushkov, Byull. Éksperim. Biol. i Med., No. 9, 24 (1957).
4. S. Bürgi, Helv. Physiol. Pharmacol. Acta, 2, 345 (1944).
5. P. Büser, P. Borenstein, and J. Brüner, Electroenceph. Clin. Neurophysiol., 11, 305 (1959).