CHANGES OF THE OCULO-VAGAL REFLEX IN MONKEYS DURING PHARMACOLOGICALLY INDUCED SLEEP

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D. I. Miminoshvili [3] observed in monkeys suffering from a neurosis, or hypnotized into a slumbering or an alert condition, changes in the electrocardiograph indicating disturbance of the coronary circulation. Analogous changes have been described in hypnosis in man [6, 7]. Clinical observations have indicated the occurrence of cardiac crises [4,8] and the occurrence of unpleasant sensations in the region of the heart [2] during short spells of sleep. In this connection it would seem worth-while to investigate the oculo-vagal reflex in monkeys during pharmacologically induced sleep, and to attempt to explain changes in the reflex which occur during the various phases of cortical inhibition found in studying the relation between the cortex and the lower centers in various cortical conditions.

METHOD

After a preliminary study of the oculo-vagal reflex in monkeys, we investigated the same reflex in barbamyl*-induced sleep in 6 rhesus monkeys, including 3 practically healthy animals (Muruk, Dergach, Muflon) and three suffering from various pathological conditions (Karabas – clearly shown neurosis, Tiger – prolonged hypertension, and Fata – marked vagotonia, and fatness due to long confinement in a small cage).

A subcutaneous injection of 80-85 mg per kg body weight of 10% barbamyl was given in the spinal region. Sleep lasted about 4 hours. The experiments were carried out in a sound-proof room, and an electrical recording of the pulse rate was made. Lead 2 of the electrocardiogram was by needle electrodes and the recording made on an ink recorder. After the animals had become used to the experimental setup, and the baseline of the normal rhythms had been established and recorded, a record was made of the oculo-vagal reflex when the animal was alert, drowsy, in deep sleep, or waking. The reflex was elicited every 10-15 minutes by pressure of the finger on the right eye for 45 seconds. For each of the phasic conditions, pressure was applied for an average of 4 times. The strength of the reflex was measured as the percentage change of the initial heart rate caused by each application of pressure to the eye. The value for the initial strength of the reflex in the alert condition was taken as the mean of several determinations.

RESULTS

Shortly after the barbamyl injection, we observed in the healthy monkeys, over a period of 20-30 minutes, a gradual increase in the value of the oculo-vagal reflex from its value in the alert state. As the sleep became deeper the value of the reflex progressively fell to zero. This second phase of the induction of sleep lasted about 20 minutes.

* Russian trade name.

During deep sleep the reflex increased somewhat in strength and attained a value intermediate between that of induction and awakening periods. During the 2nd half of the period of sleep the reflex attained or slightly exceeded the initial value. On arousal the strength of the reflex was as a rule at first greater and then fell to its original value.

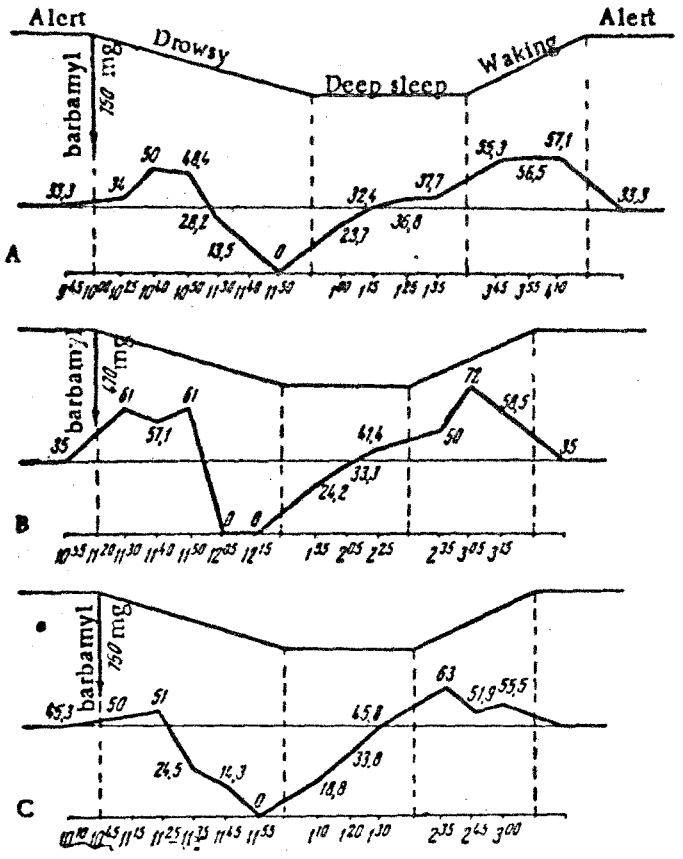

Fig. 1. Changes in the oculo-vagal reflex in normal monkeys. A) Muruk, Experiment 6/15/1955; B) Muflon, Experiment 9/23/1955; C) Dergach, Experiment 6/14/1955; Strength of the reflex expressed as a percentage of its original value for each application of pressure to the eye. Below – time in hours and minutes.

This sequence of changes in the oculo-vagal reflex during the different phases of cortical inhibition was repeated as a rule in all the normal animals (Fig. 1). The increase in the strength of the reflex during the first half of the period of induction and on arousal was found to be the same in each of the two groups. Nevertheless the pathological group showed several differences (Fig. 2). Although the reflex gradually diminished during the second half of the induction period, it did not become reduced to zero. In the second half of the sleep period the reflex value was stronger than at first, though more frequently it had a strength somewhat below the maximum value characteristic of the period of arousal.

The series of changes just described in the strength of the oculo-vagal reflex during the different phases of sleep can be explained in terms of the relations between the cortex and the subcortex.

In the first half of the period of sleep induction, we may suppose that the increase in the strength of the reflex is brought about by positive induction from the cortex, where the inhibitory process begins to become concentrated on the subcortical centers and on the vagal nuclei in particular. The progressive weakening or inhibition of the reflex in the second half of the induction period corresponds to the process of gradual irradiation of the inhibitory process from the cortex into the subcortex. The growth of the reflex during the period of

deep sleep is a result of the development and increase in strength of the process of disinhibition; this commences in the lower regions of the subcortex, including the vagal nuclei, and later reaches the higher subcortical centers as a result of a weakening of the inhibition associated with sleep. At the end of sleep the inhibitory process in the cortex has become weakened to such an extent that it is no longer able to counteract the growing strength of the disinhibitory process in the subcortex, and it is evidently this which leads to awakening. We may suppose that the increase in strength of the reflex is brought about by positive induction from the cortex into the subcortex which has been released from the effects of inhibition.

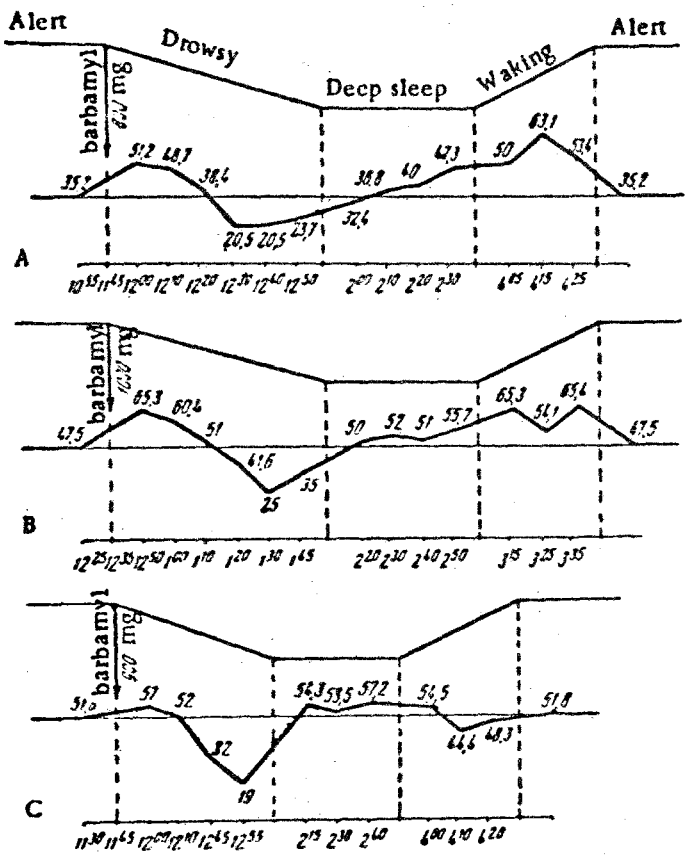

Fig. 2. Changes in the oculo-vagal reflex in monkeys with pathological disorders. A) Karabas, Experiment 9/15/1955; B) Fata, Experiment 11/20/1954; C) Tiger, Experiment 10/6/1954. The strength of the reflex is expressed as a percentage of its initial value for each application of pressure to the eye. Below — time in hours and minutes.

These explanations agree entirely with I. P. Pavlov's view [5], that mutual induction occurs during changes in the condition of sleep or wakefulness.

The differences between the changes of the oculo-vagal reflex in the two groups is probably due to a disturbance of the processes of mutual induction, brought about by a weakening of the inhibitory power of the cortical cells, and disruption of the normal central regulation of autonomic function, as a result of the neurotic imbalance in the affected group. The different forms of insomnia which are present in nervous disorders can probably be explained in the same way. It is therefore necessary in such patients to strengthen and deepen the necessary concentration of the inhibitory process in the cerebral cortex, by sleep therapy.

Our experiments showed that the strength of the unconditioned oculo-vagal reflex depends on the extent to which the inhibitory processes are distributed over the different levels of the brain during sleep, and on the inductive relationships between the cortex and the subcortical centers. At the same time the oculo-vagal reflex may

serve as an index of the depth of sleep, and the changes it undergoes may reveal the functional relationship of cortex to subcortex both in health and in various functional nervous disorders.

SUMMARY

The investigation was conducted on six rhesus monkeys—three normal and three neurotic. Sleep was induced by hypodermic injections of barbamyl. The oculo-vagal reflex (Aschner reflex) was electrocardiographically registered when the monkeys were awake, falling to sleep, during sleep and when waking up. The magnitude of each reflex elicited by pressure on the right eye was rated on a percentage scale of the initial reflex rhythms.

Typical alterations of the reflex change of the heart rhythm were found for the above-mentioned stages of sleep and wakefulness.

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