THE EFFECT OF STIMULATION OF THE DIENCEPHALON OF THE FROG WITH ADRENALIN ON CEREBROSPINAL DOMINANCE

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In nervous activity great importance is attached to the appearance of dominance, which A. A. Ukhtomskii [5] considered to be a general working principle in the work of nerve centers. A dominant focus, according to the investigations of A. A. Ukhtomskii [6] and his pupils, possesses increased excitability, persistence of excitation and the ability to summate excitation and inertia.

According to the view of A. A. Ukhtomskii [7, 8], dominant foci are continually appearing and disappearing in the nervous system as a result of external influences and the internal condition of the animal, facilitating its adaptation to the current environmental conditions. The appearance and disappearance of dominant foci play an important part in the integrative activity of the nervous system and are extremely important in pathology since the pathological appearance of dominant foci and their disappearance or, on the other hand, their prolonged persistence may bring about a distorted pathological reaction of the nervous system. For this reason it is of the greatest importance to study the mechanism of formation of dominant foci in the central nervous system and the conditions influencing their appearance and development. Great interest here in connection with the study of intercentral relationships concerns the problem of the influence of the higher divisions of the central nervous system on the dominant focus.

The aim of the present investigation was to study in the frog the influence of the centers of the diencephalon, which have the greatest subordinating influence, on the development of a dominant focus in the flexor center of the spinal cord. Stimulation of the centers of the diencephalon was effected by the action of adrenalin.

EXPERIMENTAL METHOD

The cerebral hemispheres of a frog (Rana ridibunda) were extirpated and the peroneal nerve and semitendinosus muscle exposed on one side and the peroneal nerve on the other. The frog was fixed on a test plate and placed in a humid chamber. The ipsilateral and contralateral peroneal nerves were placed on Dubois-Reymond electrodes for the purpose of stimulation. To stimulate the nerves we used an induction coil. A thyratron stimulator or a condenser discharge system with a frequency of 50 cps. The inclusion of a stimulation was recorded on a myograph and an oscillograph. A tracing of the muscle contraction was made on a myogram and simultaneously, by means of an electromyograph, on an oscillogram. The action currents from the semitendinosus muscle were picked up with silver needle electrodes through an amplifier (period of discharge – from 3 to 7000 cps) to a six-lead oscillograph. The action currents of the muscle were recorded by lead no. 1. Time intervals were recorded by sinusoids with a frequency of 50 cps. The experiments were conducted so that on a background of stimulation of the ipsilateral peroneal nerve, stimulation of the contralateral peroneal nerve was switched on and the effect of reciprocal inhibition was recorded. Next we stimulated the ipsilateral peroneal nerve with a current of specially selected frequency and strength, and after determined intervals of time the presence of reciprocal inhibition was checked.

EXPERIMENTAL RESULTS

The experimental results showed that after stimulation of the central end of the ipsilateral peroneal nerve with a current of determined frequency and strength there appeared a distortion of the effect of reciprocal stimulation, when addition to stimulation of the ipsilateral peroneal nerve of stimulation of the contralateral peroneal nerve caused, in place of inhibition, strengthening of the reflex contraction of the semitendinosus muscle. The flexor center at the same time possessed a considerable state of inertia, since the ability to distort the effect from reciprocal stimulation was maintained after the inclusion of rhythmic stimulation of the ipsilateral peroneal nerve. These signs give ground for considering that the persistent state of excitation which we created in the flexor center of the spinal cord is dominant.

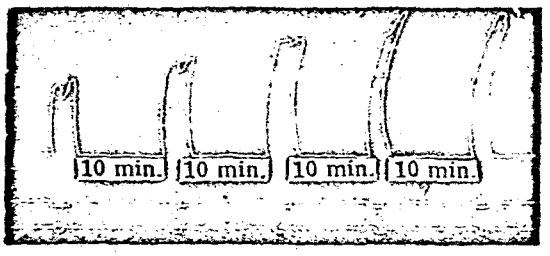

Fig. 1. Experiment No. 25. Rana ridibunda. Formation of a dominant focus in the flexor center of the spinal cord of the frog by stimulation of the ipsilateral peroneal nerve with a current composed of single sub-threshold impulses.
Interpretation of the curves (from above downwards): record of contractions of semitendinosis muscle, record of stimulation of ipsilateral peroneal nerve, record of stimulation of contralateral peroneal nerve. The figures below the records of stimulation show the distance between the coils in centimeters.

In forming spinal dominant foci in the frog by the method proposed by I. A. Vetiukov [1] and later used in work by A. M. Efimova [2], they applied rhythmic stimuli to the peroneal nerve by an induction current of frequency 40-50 cps, and intensity 2-3 cm above the excitatory threshold. In our own experiments we produced a dominant focus in the flexor center of the spinal cord by prolonged stimulation of the central end of the ipsilateral peroneal nerve with single stimuli or rhythmic impulses of current with a frequency of 10 cps, at a current strength equal to the threshold of reflex stimulation and below the threshold, and also by prolonged sub-threshold tetanic stimulation. As an illustration we show the kymogram of one of these experiments (Fig. 1).

From the kymogram it is clear that under the influence for 40 minutes of single stimulation of the ipsilateral peroneal nerve with a sub-threshold current (distance between the coils was increased to 2 cm over the threshold distance) the reciprocal inhibition gradually weakened and an enhancing effect of contraction of the semitendinosus muscle appeared on stimulation of the contralateral peroneal nerve. Weak, prolonged stimuli, causing the formation of a dominant focus and not producing the largest contractions, led to increase of the amplitude of the reflex contraction of the muscle. These facts point to an increase in the excitation of the dominant focus and to its ability to summate excitation in the form of current impulses from outside. However, with the most frequent and the strongest stimulation of the peroneal nerve, depression of the center was observed and the dominant focus disappeared. A. A. Ukhtomskii pointed this fact out previously in his work [6].

After the preliminary experiments to form a dominant focus in the flexor center of the spinal cord we moved on to investigate the effect on the dominant focus of the centers of the diencephalon, which was stimulated by the action of adrenalin. For this purpose we applied to the cut end of the diencephalon of the frog a filter paper soaked in 1 : 1000 adrenalin soltuion. Preliminary experiments were set up to study the changes in the spinal reflexes by the action of adrenalin on the diencephalon. The results obtained showed that adrenalin exhibits a biphasic action, causing at first increase and later reduction in the amplitude of the reflex contractions of the semitendinosus muscle. We show a kymogram of the experiment with the action of adrenalin on the diencephalon of the frog (Fig. 2).

From the kymogram it is clear that 2 minutes after the application of the paper soaked in adrenalin to the region of the diencephalon, the amplitude of the reflex contraction of the semitendinosus muscle was considerably increased (by 40 %). On further action of adrenalin the amplitude of the reflex contractions of the muscle began to diminish and 30 minutes after the beginning of the action of adrenalin it was greatly reduced, being 15 % of the original magnitude of the reflex recorded at the start of the experiment. Inhibition of the reflex contractions as a result of the action of adrenalin on the diencephalon of the frog was previously observed by P. A. Kiselev [3], G. A. Levitina [4] and others.

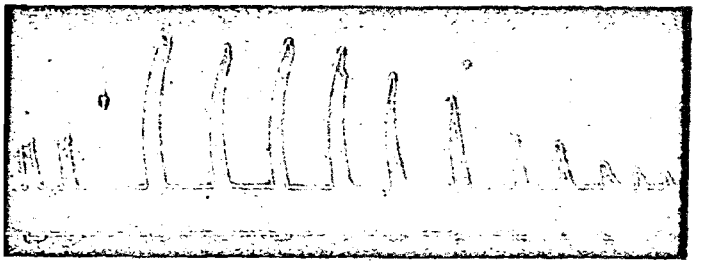

Fig. 2. Experiment No. 65. Rana ridibunda. Change in the amplitude of reflex contractions of the semitendinosus muscle by the local action of adrenalin on the diencephalon of the frog. At the moment indicated by the arrow a filter paper soaked in 1 : 1000 adrenalin was applied to the cut end of the diencephalon.
Interpretation of the curves (from above downwards): record of contraction of the semitendinosus muscle; record of stimulation of the ipsilateral peroneal nerve (2.5 v).

After removal of the adrenalin and rinsing the cut end of the brain with Ringer's solution the reflex activity of the spinal cord was restored. Since the action of adrenalin on the diencephalon of the frog in itself did not cause the contractions of the semitendinosus muscle, but when reflex contractions of the muscle were present it led to change in the amplitude of these contractions, these experiments demonstrated the influence of the diencephalon on the functional state of the spinal centers.

In later experiments we investigated the effect of stimulation of the diencephalon by the action of adrenalin on the spinal dominant focus and obtained the following results. After the development of the dominant focus in the flexor center of the spinal cord, when stimulation of the contralateral peroneal nerve produced, in place of reciprocal inhibition, stengthening of the reflex contraction of the ipsilateral semitendinosus muscle, this was still further increased by the effect of stimulation of the diencephalon of the frog by the action of adrenalin. It is interesting to note that the amplitude of the reflex contraction of the semitendinosus muscle, as in the preceding experiments, was usually diminished by the prolonged action of adrenalin, but the effect of increase of the muscular contraction due to stimulation of the contralateral peroneal nerve was retained or even increased.

As an illustration of the effect of stimulation of the diencephalon by the action of adrenalin on the spinal dominant focus we show a myogram and an oscillogram of the following experiments. On the kymogram recorded in experiment No. 113 (Fig. 3, a), it is shown that after sub-threshold stimulation of the ipsilateral peroneal nerve a dominant focus is formed in the flexor center of the spinal cord, since stimulation of the contralateral peroneal nerve produced strengthening of the reflex contraction of the semitendinosus muscle. By the action of adrenalin on the diencephalon of the frog, as may be seen from the kymogram, the amplitude of the reflex contraction of the semitendinosus muscle was gradually reduced (from 38 to 23.3 mm), however the strengthening effect of stimulation of the contralateral peroneal nerve on the reflex contraction of the muscle was increased (from 10.2 to 29.4 mm). Thus against a background of diminishing amplitude of the reflex contractions of the semitendinosus muscle due to the action of adrenalin on the diencephalon of the frog the ability of the dominant focus to summate excitation entering the central nervous system was increased. After removal of the adrenalin and rinsing the cut end of the brain with Ringer's solution, as may be seen from the kymogram, the reflex contractions of the semitendinosus muscle were increased (to 25 mm), while the strengthening of the reflex contraction arising with stimulation of the contralateral peroneal nerve was reduced (to 11.1 mm instead of 29.4 mm with the action of adrenalin).

Change in the action currents of the muscle in the dominant focus under the influence of stimulation of the diencephalon by adrenalin are shown on the oscillograms (Fig. 3, b, c). From the first oscillogram (Fig. 3, b) it is seen that on the formation of a dominant focus in the flexor center of the spinal cord of the frog, the amplitude of the action currents of the muscle arising during reflex contraction of the semitendinosus muscle was increased by stimulation of the contralateral peroneal nerve (in 84.5 %).

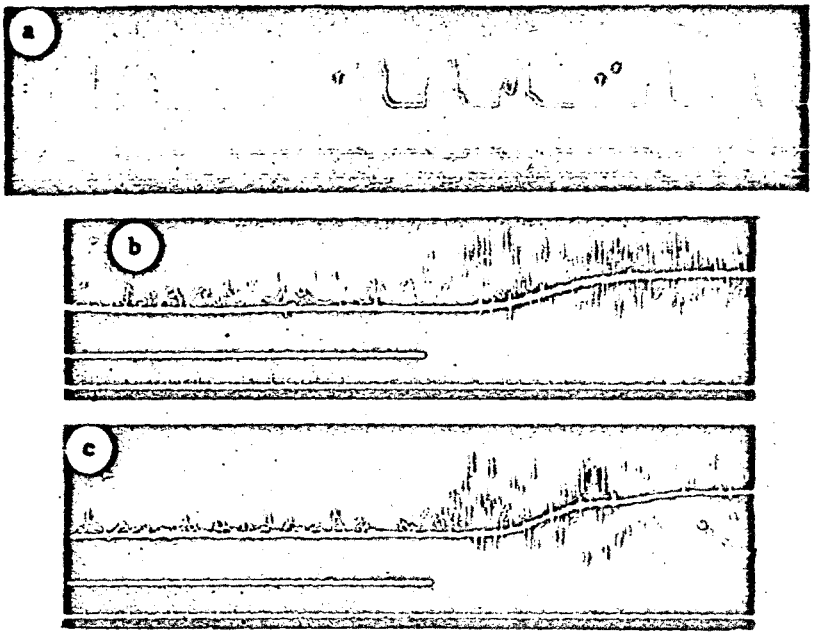

Fig. 3. Experiment No. 113. Rana ridibunda.
Stengthening of the dominant focus in the flexor center of the spinal cord by the local action of adrenalin on the diencephalon of the frog.
a) Change in the amplitude of the reflex contractions of the semitendinosus muscle by the action of adrenalin on the diencephalon of the frog against the background of the dominant focus; at the moment shown by the first arrow a filter paper soaked in 1:1000 adrenalin solution was applied to the cut end of the diencephalon of the frog; at the moment indicated by the second arrow the adrenalin was removed. The interpretation of the curves from above downward is: record of the contractions of the semitendinosus muscle; record of stimulation of the ipsilateral peroneal nerve; record of stimulation of the contralateral peroneal nerve; b) change in the action currents of the semitendinosus muscle caused by reflex stimulation by stimulation of the contralateral peroneal nerve on the background of the dominant focus. Oscillogram: c) the same, after application of a filter paper soaked in 1:1000 adrenalin solution to the cut end of the diencephalon of the frog. Oscillogram. Interpretation of the curves (from above downward): record of the action currents of the semitendinosus muscle; record of contractions of the semitendinosus muscle; record of stimulation (disappearance of the line) of the contralateral peroneal nerve; record of time (0.02 seconds).

Under the influence of stimulation of the diencephalon by the action of adrenalin, as may be seen from the second oscillogram (Fig. 3, c), the amplitude of the action currents of the muscle during reflex contraction of the semitendinosus muscle was diminished (by 25.5 %). However stimulation of the contralateral peroneal nerve at the same time caused increase of the amplitude of the action currents of the semitendinosus muscle which was greater (by 166.1 %) than before the action of adrenalin (84.5 %).

Thus, the experimental results showed that stimulation of the diencephalon of the frog due to the action of

adrenalin enhances the dominance of the flexor center of the spinal cord. In this way the increase in the amplitude of contraction and of the action currents of the semitendinosus muscle during stimulation of the contralateral peroneal nerve against the background of the reflex contraction of the muscle, observed during the formation of the dominant focus, is intensified. Intensification of development of the dominant focus in the flexor center of the spinal cord may arise concurrently with some reduction in the reflex excitability of the flexor center, since on prolonged action by adrenalin on the diencephalon of the frog reflex excitability falls, but the dominant state of the center continues to be strengthened.

The results obtained enable the conclusion that the formation of a dominant focus in the spinal cord of the frog depends on the influence of the diencephalon which, causing a change in the functional state of the spinal centers, may alter the intensity of development of dominance.

SUMMARY

Frog's diencephalon was stimulated by the action of adrenalin on the spinal cord dominant. The result of these experiments permit the conclusion that in the frog, formation of the spinal cord dominant depends on the influence of the diencephalon. The latter may change the intensity of development of the dominant by causing the change in the functional condition of the spinal cord centers.

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* In Russian