FORMATION OF A CENTRAL NERVOUS DOMINANT WHEN THE CONDITION OF THE NERVOUS CENTERS IS ALTERED BY DRUGS

S. A. Skuratova

Electrophysiological Laboratory (Head — Doctor of Biological Sciences O. V. Verzilova) Institute of Normal and Pathological Physiology (Director — Active Member of the AMN SSSR V. N. Chernigovskii) AMN SSSR, Moscow
(Presented by Active Member of the AMN SSSR V. N. Chernigovskii)
Translated from Byulleten' éksperimental'noi biologii i meditsiny Vol. 49 No. 3, pp. 12-17, March, 1960
Original article submitted February 18, 1959

It has previously been reported from this laboratory [1, 2, 3] that as a central nervous dominant develops it passes through a number of phases related to changes in the ability of the center to summate stimuli. These results have been confirmed by other workers [9, 10].

We, and others, [4 - 8, 11, 12] have shown that as it develops further, the dominant passes into a condition of parabiosis.

The results obtained may be explained in terms of the changed condition of the centers resulting from the formation in them of a dominant.

To test this hypothesis, we have tried to find whether it is possible for a central nervous dominant to be formed while the nervous centers are influenced by drugs.

METHOD

Experiments were carried out on cats under sodium amytal and chloral hydrate anaesthesia. Sixty five to seventy five mg per kg of sodium amytal was injected subcutaneously. Two hundred to four hundred mg per kg of chloral hydrate were given per rectum or by mouth. A preparation was made of the semitendinosus muscles and peroneal nerves of both hind limbs and of the deep flexors of the digits and the ulnar nerves of both forelimbs. Myograms of the reflex contractions were recorded. The central cut ends of the nerves were stimulated electrically by an induction coil. The dominant was developed in the flexor center of the hind limb by prolonged subthreshold stimulation of the afferent fibers of the peroneal nerve.

The experiments were carried out in the following order:

1) The threshold stimulation of the peroneal and ulnar nerves required to cause reflex contraction of the semitendinosus and deep digital flexors of the fore- and hind-limbs was determined;

2) The contractions of these muscles for different stimulus strengths were recorded. In some experiments, while the peroneal nerve was being stimulated to cause contraction of the semitendinosous muscle, the peroneal nerve of the opposite side and both ulnar nerves were stimulated. Normally, stimulation of the opposite peroneal nerve inhibited the reflex muscular contraction, while stimulation of the ulnar nerve had no effect or else also inhibited this contraction. Next, the nerve was stimulated so as to form a dominant. At intervals of 15 - 25 min the stimulation was interrupted, and the previous test repeated. The formation of a dominant in the hind limb flexor center was indicated by increased contraction of the semitendinosus muscle caused by simultaneous "additional" stimulation of the opposite peroneal and the ulnar nerves.

RESULTS

The depth of anesthesia was determined from the corneal reflex, amplitude and frequency of respiration, and from the response to painful stimulation. The effect obtained depended upon the depth, and varied from one animal to another.

When the anesthesia was light and the reflexes were somewhat reduced, a dominant could be formed in the flexor centers of the spinal cord by prolonged afferent stimulation of the peroneal nerve. It could be developed simultaneously in both hind limb flexor centers. As can be seen from the myograms (Fig. 1 a) recorded 90 min after injecting chloral hydrate, "additional" stimulation of the opposite peroneal and the ulnar nerve inhibited reflex contraction of the semitendinosi.

The myogram of Fig. 1 b recorded 50 min after commencing subthreshold stimulation of the ipsilateral peroneal nerves showed that "additional" stimulation of the opposite peroneal and both ulnar nerves during reflex contraction of the semitendinosi causes an increased flexor reflex on both sides.

Further subthreshold stimulation of the nerve causes the dominant to become concentrated in the center receiving the subthreshold stimulation. This can be well seen from the next myogram (Fig. 1 c) recorded 90 min after the start of subthreshold stimulation; "additional"

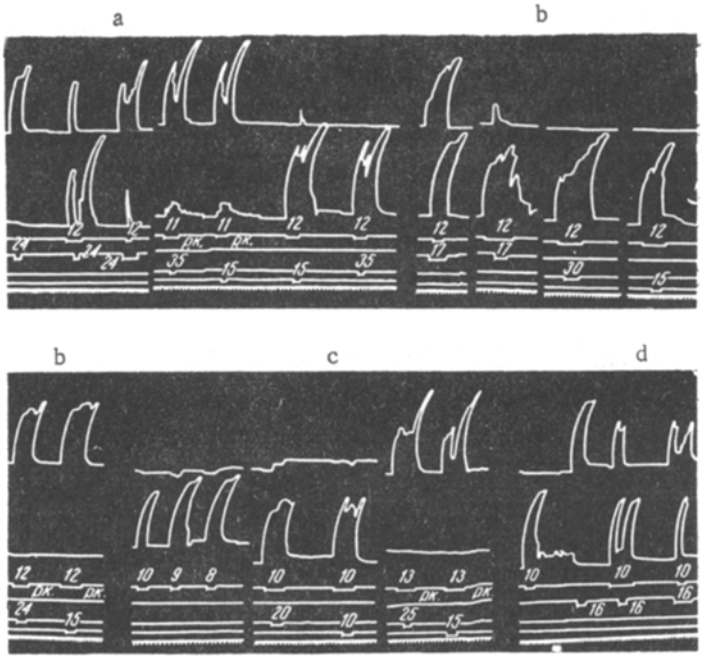

Fig. 1. Change in the semitendinosus flexor reflex caused by subthreshold stimulation of the ipsilateral peroneal nerve under light chloral hydrate anesthesia (formation of a dominant). a – Initial response, 90 min after injecting chloral hydrate; b – 50 min after applying subthreshold stimulation; c – 90 min after the onset of subthreshold stimulation; d – 150 min after subthreshold stimulation. Curves, from above downwards: Contraction of the contralateral semitendinosus muscle, of the ipsilateral semitendinosus, marker showing stimulation of the ipsilateral peroneal nerve, of the contralateral peroneal nerve, of the contralateral ulnar nerve, of the ipsilateral ulnar nerve, time marker (1 sec). The numbers over the stimulus marker indicate the distance between the induction coils in centimeters. [P. K.– stimulation of contralateral peroneal nerves.]

stimulation of the ulnar nerve results in an increased reflex contraction of the ipsilateral semitendinosus muscle, though the same stimulus causes no contraction in that of the opposite side. Fig. 1 c also shows that increasing the strength of the stimulus increases the strength of contraction, and that therefore the condition is not one of parabiosis.

When the nerve was stimulated for as long as 120 - 150 min or more, the dominant disappeared and there was once more reciprocal inhibition.

The myogram of Fig. 1 d was recorded 150 min after applying subthreshold stimuli, and it can be seen that there was no increase in the reflex contractions of either of the semitendinosi due to the "additional" peroneal stimulation, and that stimulation of the contralateral peroneal nerve produced a well-marked reciprocal inhibition.

In deeply anesthetized animals, reflexes were reduced and equalizing and paradoxical parabiotic stages developed in the spinal flexor centers. Under these conditions, parabiotic stages occurred in the flexor centers even before the application of subthreshold stimulation of the peroneal nerve.

Prolonged subthreshold stimulation of the peroneal nerves did not result in the formation of a dominant in the corresponding center but caused only a further reduction in reflex excitability, and a more profound parabiosis. Reciprocal inhibition was maintained until the end of the experiment.

In many experiments, before the subthreshold stimuli were applied during the anaesthesia, reflex excitability was reduced, though parabiotic stages either failed to develop, or else developed as far as the equalizing stage only. Under these conditions subthreshold stimulation caused only an increased inhibition and a development of equalizing and paradoxical stages in the spinal flexor centers.

The myogram of Fig. 2a was recorded 90 min after injecting chloral hydrate, and before subthreshold stimulation was commenced; it can be seen that increasing stimu-

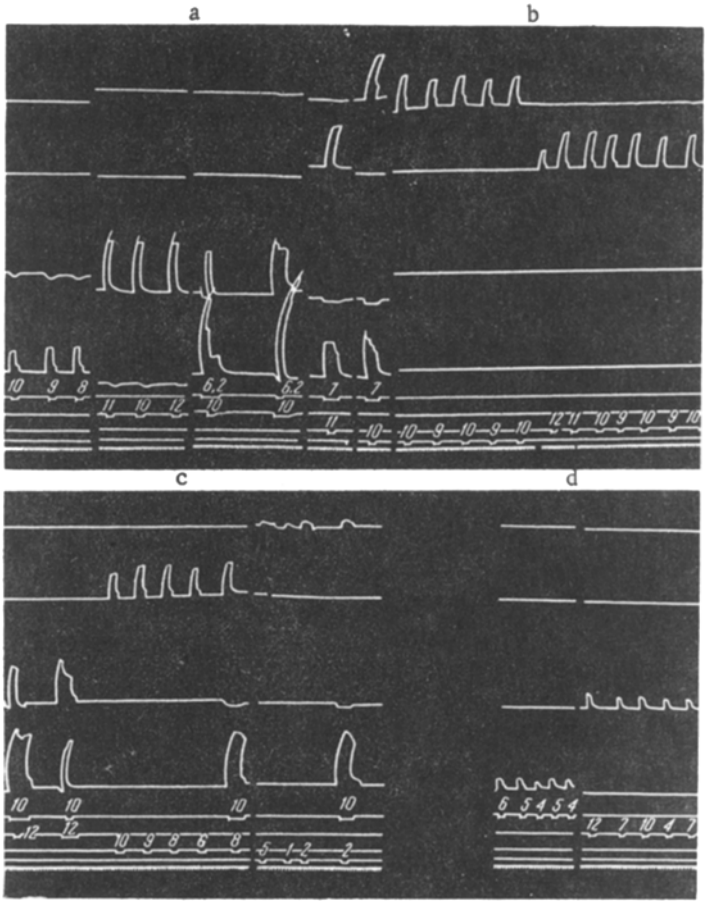

Fig. 2. Change in the reflex contraction of flexor muscles caused by subthreshold stimulation of the ipsilateral peroneal nerves in an animal under deep chloral hydrate anesthesia (no dominant formed). a – Initial response, 90 min after injecting chloral hydrate; b – 25 min, c – 60 min, and d – 180 min after commencing subthreshold stimulation. Curves, from above downwards: Contraction of the ipsilateral flexor digitorum profundus, contraction of the contralateral flexor digitorum profundus, of the contralateral semitendinosus, of the ipsilateral semitendinosus; marker of stimulus applied to ipsilateral peroneal nerve, to contralateral peroneal nerve, to contralateral ulnar nerve, to ipsilateral ulnar nerve; time marker (1 sec).

lation of the ipsilateral peroneal caused increased reflex contraction of the ipsilateral semitendinosus and that a stronger stimulus (9 cm on the induction coil scale) caused a stronger semitendinosus contraction than did a weaker stimulus (10 cm on the scale). Stimulating the contralateral peroneal nerve at a strength corresponding to 10, 11, and 12 cm distance between the coils caused a reflex contraction of the contralateral semitendinosus of almost the same strength. Here, as can be seen from Fig. 2a, the "additional" stimulation of the ipsilateral peroneal during contraction of the contralateral semitendinosus inhibited the flexor reflex. "Additional" stimulation of the ulnar nerve during reflex semitendinosus contraction had no effect on the amount of the contraction.

The next myogram (Fig. 2b) recorded 25 min after the onset of subthreshold stimulation shows the development of a paradoxical stage in the front limb flexor centers. Here stronger stimulation (9 cm) caused a weaker contraction than did the weaker stimulus (10 - 11 cm). Sixty minutes after the onset of the action of the subthreshold stimulus, reciprocal inhibition and parabiotic stages once more occurred (Fig. 2c).

Figure 2d was recorded 180 min after the onset of subthreshold stimulation, and it can be seen that the reflex contractions are now much weaker, and that paradoxical stages have occurred in the hind limb flexor centers. Strong stimulation of the ipsilateral peroneal nerve with a coil separation of 4 cm caused a smaller reflex contraction of the ipsilateral semitendinosus than

did stimulation when the separation is 5 - 6 cm. Strong stimulation with a coil separation of 4 - 7 cm applied to the contralateral peroneal nerves caused a contraction of the ipsilateral peroneal which was less than that which occurred with a weaker stimulation (10 - 12 cm separation). Under these conditions, reciprocal inhibition may be observed.

Similar observations were made on animals under sodium amytal anaesthesia.

It is important to note that during general anesthesia, the flexor centers of both fore- and hind limbs became involved in the parabiotic process as is shown by the fact that parabiotic stages are revealed by reflex excitability tests of these centers. The formation of a central nervous dominant is therefore possible under light anaesthesia, though it is considerably hindered by changes in the general excitability of the nervous centers. Under these conditions, the dominant is not stable and disappears with continued subthreshold stimulation. Under deeper anaesthesia, the excitability and liability of the spinal centers becomes greatly reduced, so that the conditions are not appropriate to the formation of dominant centers in the spinal cord. Subthreshold stimulation of a nerve now no longer induces the formation of a dominant, and leads only to an increased depth of parabiosis in the nervous centers.

When a certain depth of anesthesia has been reached, if the nervous centers are affected there is a marked reduction in their excitability and lability and it is no longer possible to establish dominant zones in the central nervous system, and previously established dominants are suppressed.

SUMMARY

Changes in nervous centers and the formation of a spinal cord dominant under the effect of chloral hydrate and sodium amytal were studied. The results showed that during subliminal stimulation of the peroneal nerve the spinal cord flexor centers could be stimulated.

When subthreshold stimulation was continued for about two hours, the dominant disappeared and was replaced by reciprocal inhibition. When anaesthesia was deep, both the reflexes and the depth of parabiosis in the flexor centers of the spinal cord were decreased. Subliminal stimulation applied to a nerve under these conditions did not induce a spinal cord dominant, but served only to cause an even greater reduction of the reflex excitation, and to intensify the parabiotic stages.

LITERATURE CITED

[1] O. V. Verzilova, Abstracts of Proceedings of the Scientific Conference in Vologda, in memory of N. E. Wedenskii [in Russian] (Vologda, 1957) p. 23.

[2] O. V. Verzilova, Byull. Éksptl. Biol. i Med. 2, 12 (1958).*

[3] O. V. Verzilova and S. A. Skuratova, Byull. Éksptl. Biol. i Med. 2, 22 (1959).*

[4] L. L. Vasil'e, Uch. Zap. Leningrad Univ. 37, 55 (1959).

[5] I. A. Vetyukov, Collected Works of the Leningrad University Physiological Laboratory [in Russian] (Moscow, Leningrad, 1930) p. 145.

[6] M. Vinogradov and G. Konradi, Med. Biol. Zhur. 2 63 (1928).

[7] N. V. Golikov, Transactions of the Second All-Union Congress of Physiologists [in Russian] (Leningrad 1926) p. 125.

[8] N. V. Golikov, Trudy Leningrad Obva. Estestvoisp. 57, 2, 57 (1927).

[9] A. M. Efimova, The Functional Condition of the Nervous Centers and Various Kinds of Dominants (Author's abstract of dissertation) [in Russian] (Leningrad, 1955).

[10] A. M. Efimova, Uch. Zap. Leningrad Univ, Ser. Biol. Nauk 43, 98 (1957).

[11] G. P. Konradi, Transactions of the Third All-Union Congress of Physiology [in Russian] (Leningrad, 1928) p. 67.

[12] A. A. Ukhtomskii Collected Works 1 [in Russian] (Leningrad 1950).

*Original Russian pagination. See English translation.