CHANGES IN LABILITY AND SPEED OF ACCOMMODATION OF SPINAL CORD CENTERS DURING INHIBITION AND GENERAL ANESTHESIA

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(Received August 5, 1956. Presented by V. N. Chernigovsky, Active Member of the Academy of Medical Sciences of the USSR)

In setting forth the theory of parabiosis, N. E. Vvedensky [1] emphasized that stimulation impulses functioning inhibitorily and alternative influences can replace each other in the emergence of the parabiotic state. From this point of view narcosis can in a wide sense be characterized as a kind of inhibition resulting from factors acting locally, while inhibition, produced, like narcosis, through physiological factors, is the result of nervous impulses. In both of these cases the inhibition represents stimulation confined to the site of its emergence. The common nature of the states of anesthesia and inhibition, according to N. E. Vvedensky, consists in the fact that in both of these states a sharp decrease in functional mobility is observed.

In experiments on spinal cats P. E. Motsny [2] detected a lowering of functional mobility and an increase in the speed of accommodation in the motor centers of the spinal cord during reciprocal inhibition. We have shown [3, 4] that during narcosis, together with the depression of reflex reactions, there is observed a lowering of functional mobility and an increase in the rate of accommodation in the motor centers of the spinal cord.

In the present research we set ourselves the goal of determining the nature of the functional changes which arise in the reflex centers of the spinal cord during reciprocal inhibition in the initial stages of general anesthesia and also of explaining whether or not the functional changes which arise are summational. The summation in the reflex centers of the spinal cord of the functional changes produced by inhibition and the changes caused by anesthesia would be one proof of the common nature of central inhibition and anesthesia.

EXPERIMENTAL METHODS

Experiments were performed on spinal cats and, in a few cases, on decerebrated cats. The narcotic agents used were: ether or chloroform as inhalation anesthetics; as intravenous or intraperitoneal anesthetics—Pentothal Nembutal and Hexenal. Recording of functional mobility and speed of accommodation in the reflex centers of the spinal cord was carried out by the myographic method [3, 4]. For the direct irritation of the motor centers of the spinal cord corresponding to the tibialis anterior and gastrocnemius muscles, the spinal cord was opened at the level of segments $\alpha_6 - S_1$ and a microelectrode (a silver wire 30 μ in diameter sealed in a glass capillary tube) was introduced from the superior surface. The position of the active tip of the microelectrode in the spinal cord was checked by histological sectioning in layers of that portion of the cord containing the electrode. Irritation of the centers was performed by means of single broken-current stimuli applied unipolarly (the anode was place on the spinal muscles). The changes in lability and speed of accommodation in the center of the spinal cord during inhibition and anesthesia were judged by the change in correlation of the height of contraction of the tibialis anterior or gastrocnemius muscle in response to the direct irritation of their centers with currents of different strength and duration. As an inhibiting nerve, for the tibialis anterior the popliteal nerve of the opposite paw was selected, and the deep peroneal nerve of the same paw was taken for the gastrocnemius. In the first

case the inhibitory volley preceded the positive one by 40-60 milliseconds, in the second by 5-10 milliseconds. The duration of the interval between irritations was determined with the use of a Hemholtz Pendulum.

In the beginning of the experiment (before anesthesia) the initial level of functional mobility and the speed of accommodation of the center under investigation were recorded. Moreover, in recording the speed of accommodation a steady ratio was obtained between the height of contraction of the muscle in response to direct irritation of the center with a rectangular current and the height of its contractions on irritation of the same center with an exponentially increasing current (H_c:H_z). In recording the background of functional mobility a steady ratio was obtained between the height of the contractions of a muscle in response to the direct irritation of its center with a current of short duration and the height of contractions in response to a current of long duration (H_c:H_d). Then the second set of these contractions of the muscle being tested were recorded, but this time against a background of a preceding volley from the inhibiting nerve. After a steady background was recorded in the normal condition and during inhibition, the animal was anesthetized and the recording of the muscular contractions was carried on simultaneously in the indicated sequence. The recording of the contractions of a muscle was accomplished according to the extent to which the animal had come out of the state of anesthesia.

EXPERIMENTAL RESULTS

The experiments showed that inhibitory volleys during light anesthesia produce in the motor centers of the spinal cord a greater than normal reduction in functional mobility.

The graph of one of the experiments, which is presented in Fig. 1, shows that an inhibitory volley induced by irritation of the contralateral popliteal nerve in the normal condition (before anesthesia) resulted in a 26% reduction in functional mobility in the motor center of the tibialis anterior. Sodium pentothal (1 ml of a 2% solution) injected intravenously into a spinal cat weighing 2.1 kg reduced functional mobility by 28%, and these same inhibitory volleys, but against a background of the animal's anesthesia, resulted in a 94% reduction in the functional mobility of the same center, i. e., more than 3 times the magnitude of the reduction in functional mobility by inhibitory volleys in the normal state. Thus during contralateral inhibition of spinal cord reflexes against a background of mild anesthesia a greater reduction in functional mobility is observed in the motor center of the tibialis anterior than during inhibition or anesthesia alone.

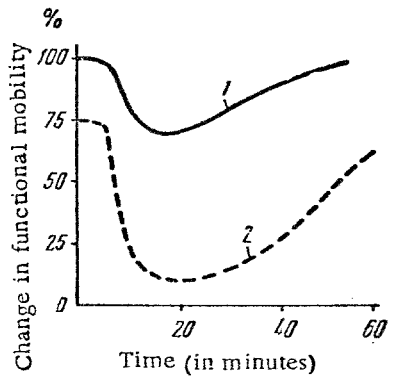

Fig. 1. Change in functional mobility in a motor center of the spinal cord of a cat (in % of the normal value) during anesthesia (1) and inhibition against a background of anesthesia (2). Test muscle: the tibialis anterior. The moment of injection of sodium pentothal is designated with an arrow.*

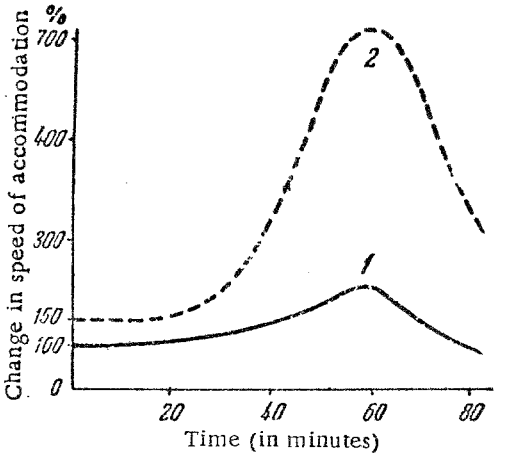

Fig. 2. Change in speed of accommodation in a motor center of the spinal cord of a cat (in % of the normal value) during anesthesia (1) and inhibition against a background of anesthesia (2). Test muscle: the tibialis anterior. The moment of injection of nembutal is designated with an arrow.*

Figure 2 contains a graph of another experiment, which illustrates the change in the speed of accommodation

*Figures do not show arrow – Publisher.

in the motor center of the tibialis anterior during anesthesia and contralateral inhibition against a background of anesthesia. The speed of accommodation of the motor center in the normal state was taken as 100%. The graph shows that during contralateral inhibition the speed of accommodation in a motor center of the spinal cord increases up to 152%. Intraperitoneal injection of 2 ml of a 2.5% solution of sodium nembutal into a spinal cat weighing 2.3 kg caused an increase in the speed of accommodation of the same center (after 50 minutes) of up to a maximum of 214%, while the same inhibitory volleys entering the motor center against a background of anesthesia caused an increase of up to 720% in the speed of accommodation of the same center, i. e., almost 4 times greater in comparison with its increase during inhibition in the normal state.

The data adduced show that nervous impulses entering the motor center of the tibialis anterior muscle from the contralateral popliteal nerve produce in it during anesthesia a considerably greater increase in speed of accommodation in comparison with the normal speed.

Analogous changes in functional mobility and speed of accommodation were also detected by us in the motor center of the gastrocnemius muscle during ipsilateral inhibition against a background of light anesthesia.

The observations showed that both contralateral and ipsilateral inhibition promotes a greater decrease in functional mobility and a greater increase in speed of accommodation in the motor centers of the spinal cord among animals which are in the state of anesthesia, regardless of by what method and by which anesthetics this anesthesia was produced. In our experiments the phenomena described were observed during anesthesia caused by inhalation of ether or chloroform as well as by intravenous injection of Pentothal and Hexenal and intraperitoneal injection of Nembutal. The intensity and duration of the changes which arise, however, depend both on the dose and nature of the anesthetic and on the method of introducing it into the organism.

A comparison of the functional changes which are characteristic of parabiosis with the functional changes observed in the motor center of the spinal cord during inhibition against a background of anesthesia enables one to characterize the latter as a typical state of Vvedensky's parabiosis.

Deepening by inhibitory volleys the parabiosis of the motor centers of the spinal cord which was produced by the anesthetics attests to the summation of the functional changes caused by both of these factors, a fact which is in agreement with the teaching of N. E. Vvedensky on the common intrinsic nature of inhibition and anesthesia.

As regards changes in functional mobility and speed of accommodation in the premotor elements of the spinal cord, in the given set of experiments, when two factors – inhibition and anesthetic – act simultaneously on the centers of the spinal cord, there is not observed in them the contrasting changes which were noted earlier by us [3, 4] in the indicated functional parameters in comparison with those of the motor centers. This is apparently explained by the fact that the parabiosis of the motor centers of the spinal cord, caused by the anesthetics and strengthened by inhibitory impulses, also encompasses in the given case the region of the premotor elements, as a result of which changes in lability and speed of accommodation are detected in them which, in their direction, are the same as those in the motor centers.

SUMMARY

Changes in the functional properties of the spinal cord during reciprocal inhibition and anesthesia were studied in spinal cats by means of direct stimulation of the spinal centers. It was noted that, during anesthesia, ipsilateral and contralateral inhibition of spinal reflexes caused a greater reduction of functional mobility and an increased rate of accommodation in the spinal motor centers than in the case of anesthesia or inhibition alone. The summation in the motor centers of functional changes caused by anesthesia and changes originated by inhibition, conforms with N. E. Vvedensky's theory on the common intrinsic nature of inhibition and anesthesia.

LITERATURE CITED

[1] N. E. Vvedensky, Excitation, Inhibition and Anesthesia,* Saint Petersburg (1901).

[2] P. E. Motsny, Fiziol. Zhur. SSSR, Vol. 36, pp. 113-139 (1950).

[3] A. D. Reva, Fiziologichny Zhurnal Akademy Nauk Ukrainskogo SSR, Vol. 1, No. 2, pp. 21-29, (1955).

[4] A. D. Reva, in the book: Abstracts of Papers Presented at the VII All-Union Conference of Physiologists,* Moscow, pp. 502-503 (1955).

* In Russian.