SUBORDINATING EFFECT OF THE DIENCEPHALON ON ACCOMMODATION OF THE SCIATIC NERVE

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(Received July 25, 1957. Presented by Active Member Acad. Med. Sci. USSR V. N. Chernigovskii)

D. N. Nasonov and collaborators have recently [3] questioned the existence of subordinating influences of the central nervous system on the physiologic properties of the peripheral nerve trunks. Their views were based on the fact that subordinating influences had been demonstrated by the use of transection or ligation of the nerve. Since such interference with the nerve represents not only interruption of connection of its distal part with the central nervous system but also a traumatic influence inflicted on the nerve itself, the changes in the physiologic properties of the nerve induced by such procedure may be the result not only of interruption of its connection with the brain but also of trauma to the nerve itself.

The question concerning the existence of subordinating influences of the central nervous system on the nerve can only be resolved by such experiments in which action is directed against the central nervous system with preservation of its connection with the nerve under investigation, i.e., without transection or ligation of the latter.

Experiments of this sort have been described by P. E. Motsnyi [2] who concludes that Sechenov inhibition as well as direct stimulation of the sympathetic trunk in frogs lead to lowering of accommodation of the sciatic nerve. However, the conclusions made by the author do not follow from his data as we found on analysis of the myograms presented in his paper. Motsnyi assesses the accommodation of the nerve by the ratio of two values – the height of muscular contraction in a nerve-muscle preparation in response to stimulation of the nerve with square-wave current (N_s) and the height of such contraction in response to stimulation of the nerve by exponential current of a certain height (N_e), i.e., $N_s : N_e$.

As the author mentions, N_s is an index of excitability and N_e an index of accommodation. This method is permissible, although it is more expedient to measure accommodation not with a single gradient of current rise, but several, since that determins the whole accommodation curve. But when such a method is used it is necessary to take into account that a change in the ratio $N_s : N_e$ indicates a change is brought about by a change in N_e. The myograms presented in Motsnyi's work however, show that in his experiments N_s and not N_e underwent changes, while the latter remained almost unchanged. Consequently, the changes described in Motsnyi's paper refer not to accommodation but to the excitability of the nerve on square-wave stimulation. This, of course, does not exclude the possibility that changes in accommodation also took place; but determination of several points along the accommodation curve, which was not done by the author, is necessary for detailed judgement.

The question regarding subordinating influence of the higher centers on the rate of accommodation of peripheral nerve thus remains open and still requires experimental confirmation.

EXPERIMENTAL METHODS

In our experiments the subordinating influence of the higher centers on the accommodation of peripheral nerve was investigated with determination of the accommodation curve using 4 gradients of stimulating current

rise, viz.: successive connection of capacities of 1/1000, 1/100, 1/10 and 1μf. Prior to determination of the excitability threshold of the nerve with respect to these gradients its threshold with respect to square-wave stimulation (rheobase) was measured; minimal contraction of the muscle served as index. Experiments were performed on thalamic frogs (extirpation of cerebral hemispheres by the I. M. Sechenov method). We studied changes in accommodation in the presence of Sechenov inhibition (application of a crystal of rock-salt to the sectioned optic thalami for 2 minutes) and also on stimulation of the skin of the dorsal surface of the shin by applying to it a piece of filter paper (1 × 1 cm) moistened with a 0.5% solution of sulfuric acid. The preparation was placed into a moist chamber; the experiments were begun 1-1½ hours later. In the early experiments stimuli were applied at 1 minute intervals during the determination of the rheobase and accommodation; in subsequent experiments half-minute intervals were used since this did not affect the values obtained.

EXPERIMENTAL RESULTS

Our experiments demonstrated that in the presence of Sechenov inhibition marked lowering of accomodation takes place, chiefly with respect to stimulating currents of small gradient: with capacities of 1/10 and 1μf the threshold is halved and more. The rheobase is lowered slightly, by approximately 25-30%. Unlike P. E. Motsnyi, we observed these changes over a prolonged period; after removal of the salt crystal from the sectioned optic thalami the changes continue to grow and then slowly diminish and return almost to the initial values after 40-60 minutes (Fig. 1, A). The fact that Motsnyi observed a change in the ratio $N_s : N_c$ only during stimulation of the sectioned optic thalami is probably accounted for by the fact that he did not determine the whole accommodation curve but only one of its points which, moreover, was close to the rheobase.

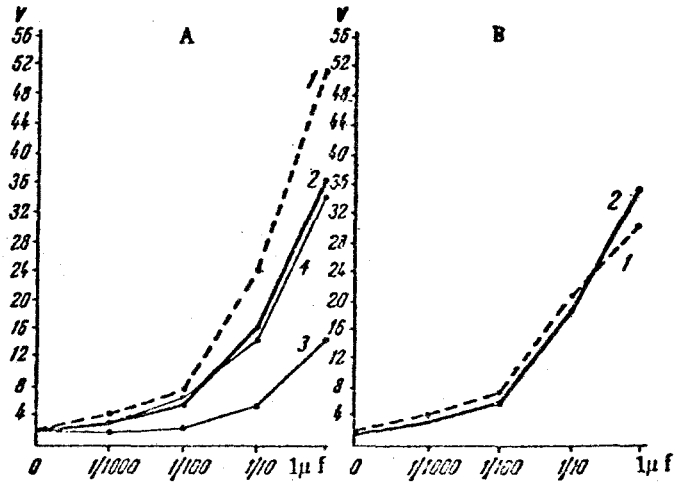

Fig. 1. Effect of Sechenov inhibition on accommodation of the sciatic nerve in frog.
A) Thalamic preparation. Nerve accommodation curve; 1) before and 2) during Sechenov inhibition; 3) 10 minutes after and 4) 25 minutes after removal of rock-salt from optic thalami. B) Thalamic preparation. Similar experiment with nicotine-blocked sympathetic trunk; 1) before and 2) during Sechenov inhibition.

Slowing of accommodation in Sechenov inhibition is also noted when the spinal cord is transected in the lower thoracic region. Following painting of the sympathetic trunks with a 1% solution of nicotine, Sechenov inhibition no longer induces a change in nerve accommodation (Fig. 1, B); in this respect our data diverge from Motsnyi's data who continued to observe the described phenomenon after section of all r.r. communicantes leading to the sciatic nerve.

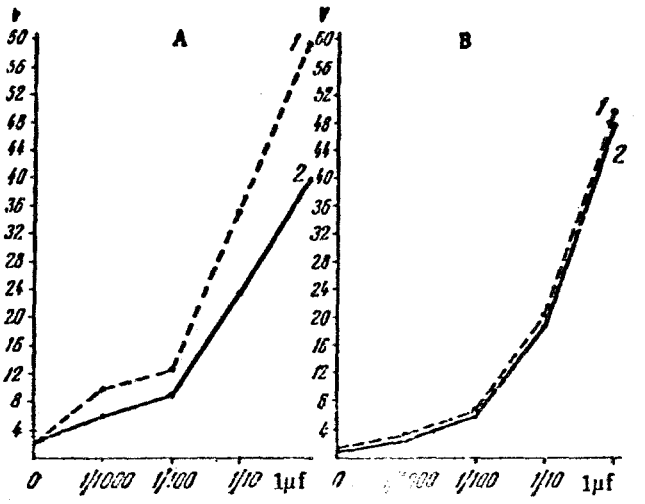

Fig. 2. Effect of cutaneous stimulation (shin) with 0.5% solution of sulfuric acid on accommodation of the sciatic nerve in frog. A) Thalamic preparation. Accommodation curve for the nerve: 1) before and 2) during cutaneous stimulation. B) Bulbar preparation. Nerve accommodation curve: 1) before and 2) during cutaneous stimulation.

In experiments in which the skin of the frog's leg was stimulated with acid, as in Sechenov inhibition, lowering of accommodation was observed (Fig. 2, A). This effect is not observed when the experiment is performed on a bulbar or spinal preparation rather than on a thalamic one (Fig. 2, B).

A study was also made of changes in accommodation of the sciatic nerve which occur on nicotine-blocking of the sympathetic trunk in the absence of stimulation of optic thalami and skin of the leg. It was found that exclusion of the sympathetic trunk in itself lowered accommodation; the effect however was slight. It was observed only on the side ipsilateral to the affected sympathetic trunk; accommodation of the contralateral nerve remained unchanged (Fig. 3, A). The effect of destruction of the spinal cord with preservation of the brain stem was also investigated; the sympathetic trunk was left intact in these experiments. Such interference with the central nervous system did not alter the accommodation of the sciatic nerve (Fig. 3, B).

The present series of experiments, using accommodation of the sciatic nerve as an example, has proved that the functional state of peripheral nerve trunks is, contrary to the opinion of D. N. Nasonov and his collaborators, subordinated to the central nervous system. The subordinating influences on accommodation of the sciatic nerve demonstrated by us originate in the diencephalon (which, naturally, does not exclude the possibility of the existence of such influences in other, more particularly higher, parts of the central nervous system).

The fact that lowering of sciatic nerve accommodation upon stimulation of the optic thalami does not occur if the sympathetic trunk is excluded by nicotine suggest that the subordinating influence of the diencephalon on accommodation of this nerve is mediated by the sympathetic pathway (fine nonmedullated nervi nervorum of the type of Timofeev's fibers described by I. V. Torskaia [7]).

The diencephalon exerts a subordinating influence on sciatic nerve accommodation not only in the presence of stimulation of the optic thalami and leg skin, but also in the absence of these stimuli. This is demonstrated by those experiments in which the sympathetic trunk was excluded from the sphere of action in frogs which had not been subjected to such stimulation. Judging by the fact that such exclusion of the sympathetic trunk, as well as stimulation of the optic thalami and leg skin, lead to lowering of sciatic nerve accommodation (although less marked in the former case), it may be concluded that the diencephalon subordinates sciatic nerve

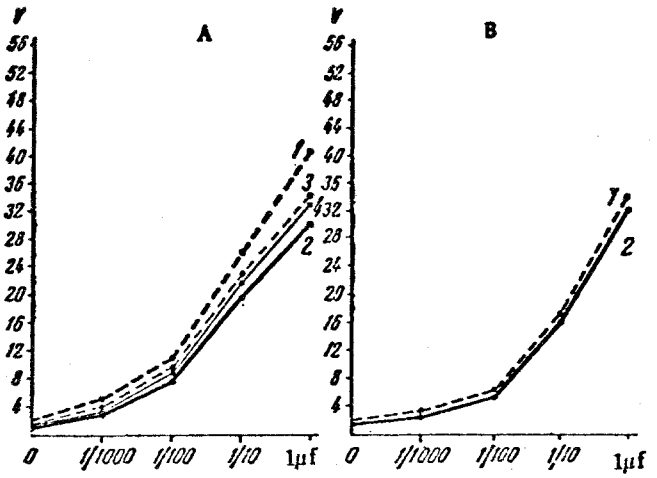

Fig. 3. Effect of exclusion of the sympathetic trunk and destruction of the spinal cord on sciatic nerve accommodation in frog.
A) Thalamic preparation; 1) and 2) accommodation curves for the right sciatic nerve before and after exclusion of the right sympathetic trunk by means of nicotine; 3 and 4) corresponding accommodation curves for the left sciatic nerve.
B) Thalamic preparation. Sciatic nerve accommodation curve: 1) before and 2) after 10 minutes following destruction of the spinal cord. Sympathetic trunk preserved.

accommodation when the diencephalon is not stimulated; exclusion of the sympathetic trunk abolishes this subordinating influence.

The character of the subordinating influence exerted by the diencephalon on sciatic nerve accommodation thus depends on the functional state of the diencephalon; in a state of rest the diencephalon maintains a high degree of sciatic nerve accommodation but lowers such accommodation when it is in a state of activation.

The possibility is not excluded that lowering of accommodation is an adaptive-trophic effect which ensures adaptation of the nerve to the working requirements of the organism; lowering of accommodation, as shown by L. V. Latmanizova [1] is associated with increase in lability ensuring adoption of the rhythm of inflowing impulses by the nerve. This point of view is supported by the subordinating influences of the diencephalon on the sciatic nerve being mediated by the sympathetic pathway. It is known that the same pathway has been found by A. V. Tonkikh to be involved in the Sechenov inhibition of the spinal cord.

The absence of change in sciatic nerve accommodation on destruction of the spinal cord with conservation of the diencephalon also indicates that the subordinating effect of the central nervous system on accommodation of peripheral nerve trunks is sympathetic in character.

The data mentioned above suggest that the subordinating influence of the central nervous system on accommodation of peripheral nerves is one of the manifestations of the universal adapative-trophic action of the sympathetic nervous system, as established by the school of L. A. Orbeli.

The present experiments permit the conclusion that Sechenov inhibition lowers the rate of sciatic nerve accommodation sharply and for long periods (20-40 minutes). This effect is also observed in preparations subjected to preliminary transection of the spinal cord in the thoracic region, but is absent when the sympathetic trunks are blocked by nicotine.

Cutaneous stimulation achieved by application of a sulfuric acid solution to the shin of a thalamic frog results in the reflex lowering of sciatic nerve accomodation. This effect is absent in bulbar and spinal preparations.

Nicotine treatment of the sympathetic trunk by itself also causes some lowering of sciatic nerve accomodation, but the effect is slight. It is only observed ipsilaterally.

Destruction of the spinal cord does not affect the sciatic nerve accommodation in a thalamic preparation.

The facts cited prove that accommodation of peripheral nerve trunks is subordinate to the central nervous system. This subordination is achieved by the diencephalon and is mediated by the sympathetic trunks; it is evidently of adaptive-trophic significance.

SUMMARY

It was established on thalamic frogs operated by I. M. Sechenov's method that accommodation of peripheral nerves is subordinate to the central nervous system and depends on the functional condition of the diencephalon. The latter enhances it in conditions of rest and decreases it during activity (Sechenov's inhibition, reflex excitation). This subordination is carried out by the diencephalon by way of the sympathetic trunks and evidently has an adaptive trophic significance.

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