THE REFLEX ACTIVITY OF THE STERNOCLEIDOMASTOID MUSCLES IN ONTOGENESIS

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The functional evolution of reflex acts is of great theoretical interest. It has been shown in our laboratory that in the earliest period of ontogenesis of mammals which are born blind, the musculature is prepared to assume tonic functions and, although imperfect, a redistribution of tone may be observed on account of the centers of the brain stem [1, 4, 6-9].

The presence of joint excitatory-inhibitory relationships between the centers of the spinal cord in early ontogenesis is recognized by several workers [3]. Reciprocal inhibition was observed in A. A. Volokhov's laboratory in cat and rabbit embryos [10]. We have previously studied the reflexes of the cervical muscles of adult animals [2].

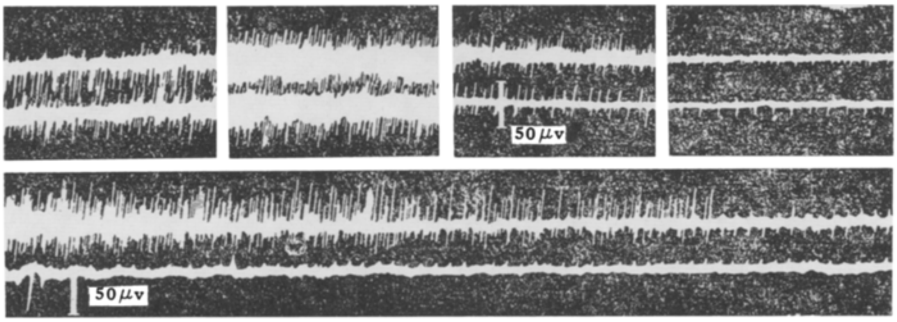

Fig. 1. Reflex reactions of the cervical muscles from the labyrinths. A) One-day old rabbit: a) head turned 15° to the left; b) 45° to the left; c) 60° ditto; d) 90° ditto; top curve—potentials of the right sternomastoid muscle, bottom curve—potentials of the right cleidomastoid muscle; B) two-day old rabbit: rotation of the head 20° to the right; top curve—potentials in the left, and bottom curve—potentials in the right sternomastoid muscles.

The object of the present investigation was to study the establishment of tone and the development of proprioceptive reflexes of the cervical muscles in ontogenesis. This problem has been inadequately studied. The only work was done by M. A. Kalugina [5], who studied the morphology of the proprioceptive apparatus of the biceps and sternocleidomastoid muscles in mouse embryos and in newborn rats, and demonstrated that the structure of the proprioceptors became increasingly complicated with age.

EXPERIMENTAL METHOD

The sternocleidomastoid muscles were dissected under light ether anesthesia. The distal tendons of the sternomastoid and cleidomastoid muscles were attached to a thread passing over a pulley. The electrical potentials of the muscles were recorded from needle electrodes by means of a two-channel oscillograph. Altogether 32 observations were made on rabbits aged from a few hours to one month.

EXPERIMENTAL RESULTS

The sternocleidomastoid muscles of young rabbits were found to possess the power oi tonic contraction a few hours after birth. For instance, after they had been detached from their insertion, the muscles shortened by approximately 20% of their initial length. In a state of relative rest these muscles possessed electrical activity which reached 5-10 μv, with a frequency of the impulses of about 70 sec.

The tone of the investigated muscles depended on the position of the head in space (a reflex from the labyrinths). If the rabbits were fixed on their backs the muscles showed greatest activity when the head was brought towards the sternum. If the rabbit's oral fissure was situated at an angle of 90° to the horizontal, the amplitude of the potentials of the sternomastoid and cleidomastoid muscles of the young rabbits was 40-60 μg during the first few days after birth. With subsequent extension of the head (the oral fissure at an angle of 135-140° to the horizontal), the activity of the muscles fell to 2-5 μv or was absent.

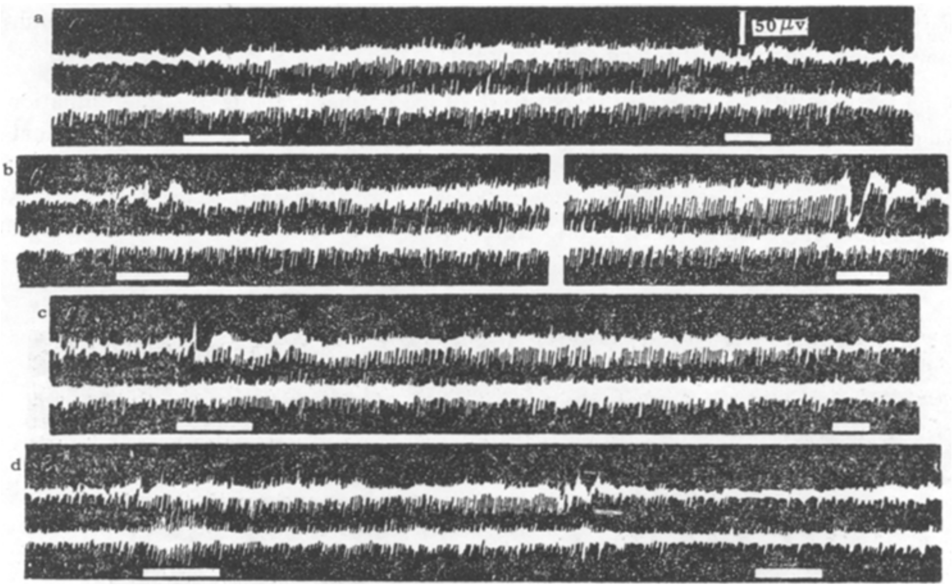

Fig. 2. Reflex reactions of the neck muscles of a 1-day old rabbit to stretching. a) Stretching the right cleidomastoid muscle with a weight of 3 g; b) ditto with a weight of 4 g; c) ditto 7 g; d) ditto 10 g; top curve—potentials of the right sternomastoid muscle; bottom curve—potentials of the right cleidomastoid muscle; the white bands below the curves denote attachment and removal of weights.

Reflexes from the labyrinths acting on the cervical muscles were also observed when the animal's head was rotated around the longitudinal axis of the body. When this was done, from a few days after birth the reciprocal relationships between the symmetrical muscles could be clearly observed.

At a definite angle of rotation of the head to the right, the activity of the test muscles was increased on the left side and decreased on the right. Conversely, if the head was rotated to the left, the tone of the muscles on the right was increased, while those on the left were relaxed.

The presence of reciprocal relationships between the symmetrical opposite cervical muscles in early ontogenesis indicates that states of coordinated inhibition may develop even during the first days of life.

However, a reflex from the labyrinths to the neck muscles of the young rabbits was observed in early ontogenesis only in response to slight rotation of the head around the longitudinal axis of the animal's body (from 0°—vertex downwards—to 60°). With a further increase in rotation, the activity of the corresponding muscles decreased or disappeared. In some experiments depression of the activity of the neck muscles was observed even during smaller turning movements of the head. Moreover, the reaction from the labyrinths on the neck muscles of the young rabbits decreased in the course of time, despite the fact that the head continued to occupy an incorrect position in relation to the trunk. Depression of the activity developed the more quickly the younger the animal. A similar depression of the reflex reaction from the labyrinths was recorded by M. V. Korovina [7] on the eye muscles of newborn rabbits.

The reflex reactions of these muscles in response to changes in the position of the head of the young rabbits are illustrated in Fig. 1. If the head of a 1-day old rabbit (A) was turned 15° to the left (a), the amplitude of the potentials of the sternomastoid muscle was 40 μv, and that of the cleidomastoid 30 μv. Maximal activity of the muscles was observed when the head was rotated 45°, when the coresponding amplitudes were 80 and 50 μv (b), and the frequency of the oscillations also rose. On increasing the angle of rotation to 60°, the amplitude of the potentials in both muscles fell to 30 μv (c), and the frequency of the discharges from the cleidomastoid muscle decreased considerably. The electrical activity disappeared when the head was rotated through 90°.

The oscillogram B shows the activity of the sternomastoid muscles of a 2-day old rabbit with its head fixed at an angle of 20°. The potentials of the left muscle were 100 μv in amplitude, while in the right muscle they were absent. The activity in the left muscle weakened 11 seconds after rotation, and then disappeared, although the head remained in the previous position. Thus the reflexes in the neck muscles from the labyrinths in early ontogenesis are characterized by little stability and by low lability.

In view of the low stability of the reflex mechanisms of the newborn rabbits, the transformation of the reaction of intensified electrical activity of the cervical muscles into a reaction of intensified electrical activity of the cervical muscles into a reaction of depression may be explained from the point of view of a reflex pessimum of the centers of the muscles under examination. However, we do not fully exclude the possibility that a reduction in the discharges from the receptors takes place, although the specific responses from stretching the muscles do not confirm this suggestion.

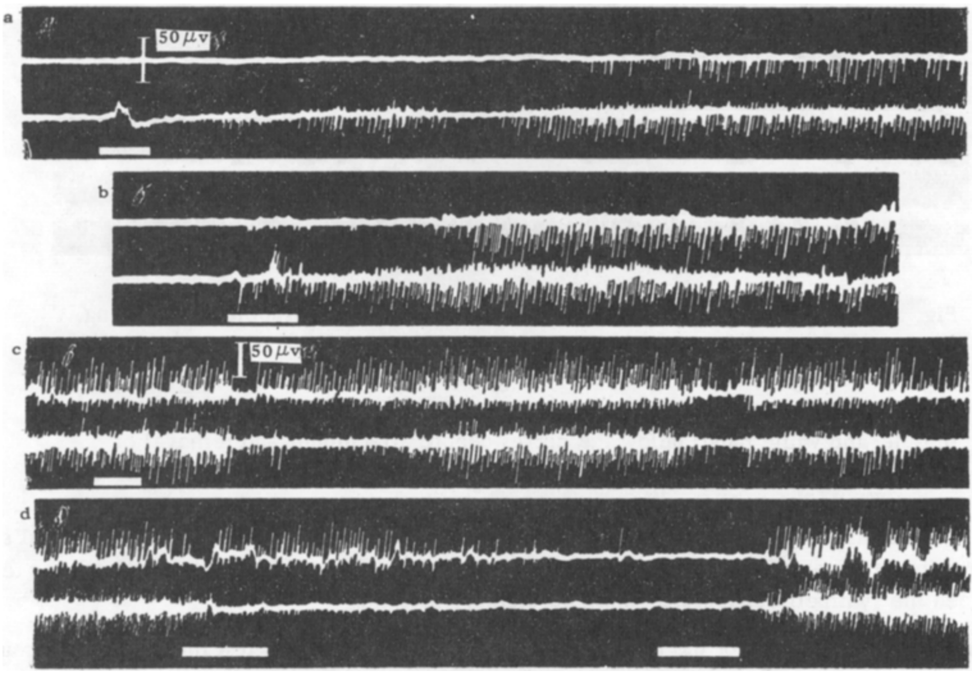

Fig. 3. Excitation-inhibition relationships in the centers of the cervical muscles. a, b) a 2-day old rabbit: top curve—potentials of the left, and bottom curve—potentials of the right cleidomastoid muscles during stretching of the right muscle successively with weights of 10 and 15 g; c, d) a 1-day old rabbit; top curve— potentials of the left, bottom curve—potentials of the right sternomastoid muscles during stretching of the right muscle successively with weights of 4 and 10 g; the white bands below the curves denote attachment and removal of the weights.

The sternocleidomastoid muscles of the newborn rabbits showed a proprioceptive stretch reflex, as shown by an increase in their tonic activity. This increase in the activity of the muscles was observed only in response to moderate loads, and it was accompanied by irradiation of the proprioceptive excitation to the contraction and ipsilateral muscles.

The activity of the right sternomastoid and cleidomastoid muscles of a 1-day old rabbit is recorded in Fig.2. Stretching the sternomastoid muscle with a load of 3 g caused its activity to increase from 15 to 40 μv, and the irradiation of the excitation to the other muscle was insignificant (a). With a load of 4 g the tonic potential of the stretched muscle was 60 μv, and that of the cleidomastoid muscle was 40 μv (b). With an increase in the load to 7 g, the reaction in both muscles was decreased (c). A load of 10 g caused a small increase in activity at the beginning of stretching, followed by the development of depression (d).

During the study of proprioceptive stretch reflexes in ontogenesis, different variants could be noted both in the development of excitation and in the development of inhibition. If the stretching was carried out against a background of existing activity, proprioceptive excitation at once took hold of the muscle. In the absence of activity, the reaction to stretching developed after a brief latent period, sometimes amounting to 1-2 seconds. In these cases irradiation of the excitation to neighboring muscles was observed, as a rule, later than the main process.

Depending on the loads applied, the character of the depression also changed. In the experiments with small weights, depression of activity developed gradually as the weight acted. In this case the depression could be accounted for by fatigue of the preparation, especially because the activity was not restored after removal of the weight. If the stretching was excessive, depression developed quickly, and recovery took place immediately the weight was removed.

In individual experiments synchronized depression and intensification of the activity of both muscles was registered when one of them was stretched. A similar clonus in response to stretching was observed by A. P. Marevskaya [9] in the muscles of mastication of newborn rabbits.

We present the oscillograms obtained in two experiments (Fig. 3). Before stretching activity was absent in both muscles of the 2-day old rabbit (a, b). When the right cleidomastoid muscle was stretched (10 g) activity developed at once in that muscle, and later in the contralateral muscle. With an increase in the load (15 g), the proprioceptive reflex and irradiation of the excitation became more marked and appeared sooner.

In the 1-day old rabbit (c, d) both muscles had an initial electrical activity of 50 μv. Stretching the right muscle with a weight of 4 g was accompanied by changes of activity, occurring in different phases. Bursts of oscillations alternated with periods of depression, synchronously in both muscles (c). A weight of 10 g was too heavy for this animal, and caused depression of the stretch reflex (d). Depression developed rapidly in the stretched muscle, and more gradually in the other. The difference in the development of depression of activity of the different muscles in these conditions is evidence against fatigue or inhibition of the receptors, and indicates pessimal inhibition, at first in the center of the muscle which was stretched, and later in the other centers. As soon as the weight was removed, the tone of both muscles was restored.

It must be pointed out that the size of the weight causing depression of the stretch reflex increased with age, proportionally to the increased strength of the muscle.

It may be concluded from these results that the sternocleidomastoid muscles of rabbits possess a stretch reflex from within a few hours after birth. When this reflex is brought into action by the labyrinths, reciprocal relationships develop between the centers of these muscles. All the reactions observed in early ontogenesis are characterized by instability and by great inconstancy, and they improve with age.

SUMMARY

Electrophysiological method was used to study the reflex activity of the sternocleidomastoid muscle of the newborn rabbits beginning from the first hours after birth. Excitatory-inhibitory relations between the symmetrical centers of these muscles were present. With the progress of age both the reflex from the labyrinths and the proprioceptive extension reflex become more stable; the excitatory inhibitory structure of the reflex reactions is seen to improve.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.