DEVELOPMENT OF PROPRIOCEPTIVE REFLEXES IN THE MUSCLES OF MASTICATION

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Investigations on the development of reflexes show that the proprioceptor reflexes are among the first to develop [1]. Reflex response to stretching the muscles of the limbs in embryo cats and newborn kittens have been described several times [2,6].

It has been shown that reflexes involving mouth movements are well-developed in the embryo [3,4,5,7, 8], but no precise description of the development of the masticatory reflexes has been given as yet.

The present investigation concerns the tone of the masticatory muscles (m. masseter) and the reflex response to stretching them in animals in the early postnatal period.

EXPERIMENTAL METHODS

The experiments were made on 36 kittens at times from 2-3 hours to 30 days after birth. A cathode ray oscillograph and amplifier [4] was used to record the activity of the masticatory muscles. The animals were placed in a screened room. Fine needle electrodes were inserted into the central and distal portions of the muscles. To stretch the muscle a load was hung on the lower jaw, or else the muscle was partially separated and a load attached to the distal end. The distal end of the m. masseter was separated together with a small portion of bone. During the experiments the cats were kept under light ether anesthesia.

EXPERIMENTAL RESULTS

A. Tonic innervation at rest. These experiments established the presence of a tonic innervation of the jaw muscles in kittens 2-3 hours after birth.

The greatest electrical activity in the m. masseter occurred while feeding on milk. The amplitude of the potentials varied from 20 to 35 microvolts, and the discharge frequency was 120-130 per second. Later the amplitude of these potentials was reduced. Thus, while on the 13-14th day it had a value of 14-16 microvolts, at the end of the month it usually did not exceed 10 microvolts. The discharge rate was also reduced to 100-110 per second.

B. Reflex response to stretching the jaw muscles. Proprioceptor stretch reflexes in kittens are of the same general type as those in adult animals, but there is some variation with age, and in kittens the reflexes are not well-maintained and are rapidly inhibited. In kittens there is a widespread irradiation of proprioceptor excitation in the central nervous system. As in adult cats, the effect depends to a great extent on the amount the muscle is stretched.

The following are the experimental results. In kittens aged 0 to 5 days the m. masseter was stretched by a load of 10-20 g applied to the jaw, and this caused an increase of 10-15 microvolts in the amplitude of

the oscillations above the resting value, and a considerable increase in frequency. Further increase in the load caused a clonus of the lower jaw, and if the load did not exceed 50 g this was maintained as long as the tension was applied. If the load was greater (up to 100 g) clonus occurred only during the first few seconds, and then either ceased altogether or else appeared again after a short interval. Further increase of the load up to 110-200 g caused 2-3 clonic movements of the lower jaw which was followed by an almost complete relaxation of the muscle. The clonus took the form of rapid incomplete jaw closures. The electromyograph trace showed separate high amplitude impulses alternating with groups of low amplitude potentials (Fig. 1).

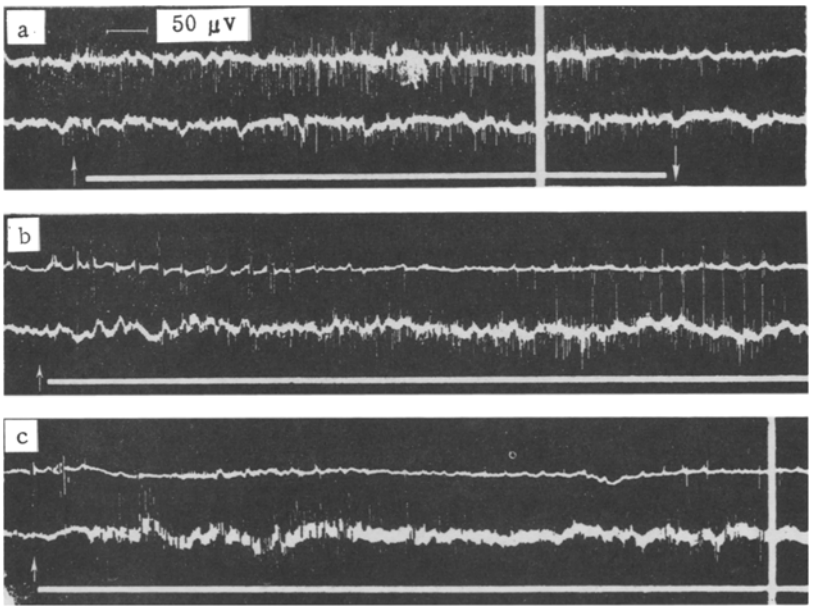

Fig. 1. Electrical changes in tensed and untensed muscles. Upper trace: Tensed muscle (m. masseter), lower trace – m. digastricus.

Load applied to jaw: a) 20 g, initial amplitude of oscillation 30-40 microvolts; with tension of 40 g – 50 microvolts, individual impulses 70 microvolts; b) 50 g, c) 100g: b) and c) clonic jaw movements in response to tension.

Experiment on cat 2 hours after birth. In all traces ↑ indicates application of load, ↓ – time of removal of load.

At the age of 5-15 days a load of 20-50 g, and from the 15-30th day a load of 50-100 g usually gave a uniform increase in the amplitude of the potentials and an increase in the frequency for the whole period for which the tension was applied. Greater loads applied subsequently caused large volleys of impulses which lasted from a fraction of a second to several seconds depending on the extension of the muscle. The large potentials alternated with small ones which sometimes occurred only occasionally, and at other times had quite a high frequency. An excessive tension of 200-300 g caused an initial increase in the discharge followed by an inhibitory effect (Fig. 2).

In the above experiments the tension was applied to the m. masseter by attaching weights to the lower jaw. With this arrangement, besides the receptors of the masseter muscles, the sensory endings of the whole group of muscles of mastication (m. temporalis and m. pterygoideus), as well as those of the skin round the mouth might be stimulated. Control experiments showed that the principal effect in the contraction of the masseter muscle was mediated by stimulation of proprioceptors in this muscle itself. This was shown in experiments in which the masseter muscle was stretched via the jaw after denervation of all the other jaw muscles on both sides, and also when the skin and subcutaneous tissue round the mouth were anesthetized. In experiments

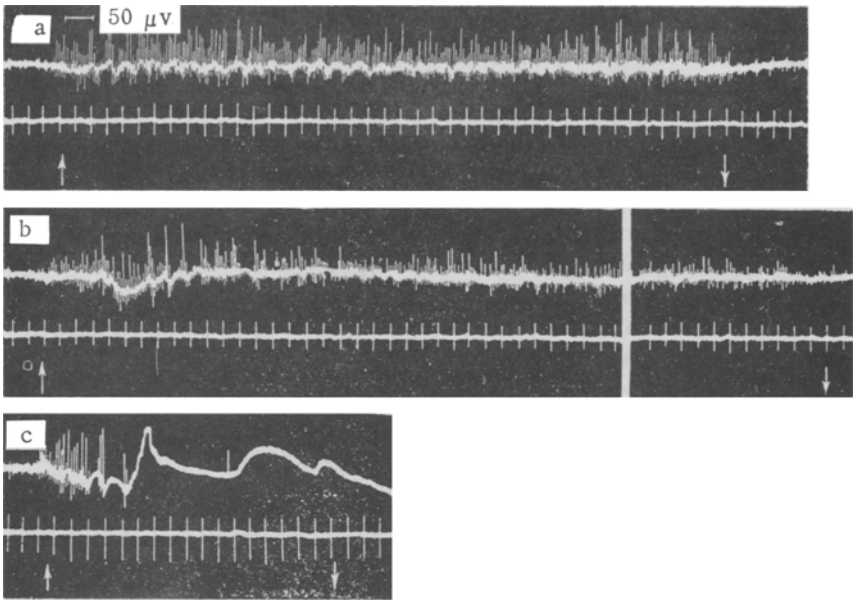

Fig. 2. Effect of tension on potentials in m. masseter in 5 day kitten. Upper trace – electrical discharges in the muscle; lower trace – time intervals of 0.1 seconds. Tension of muscle through load on jaw: a) 50 g, b) 150 g, c) 200 g.

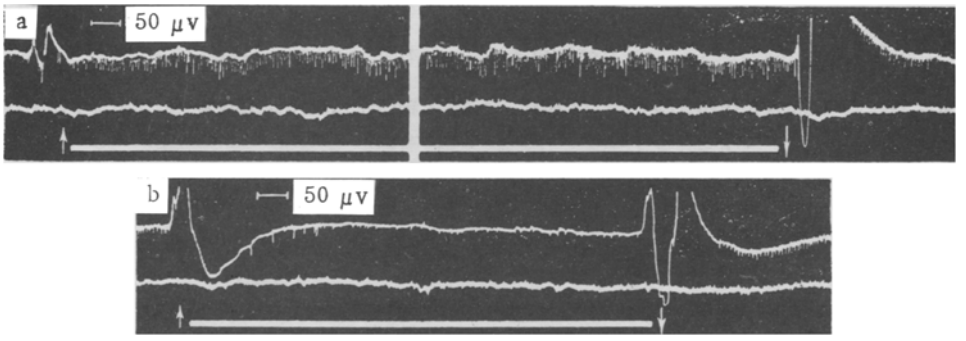

Fig. 3. Electrical changes on stretching the muscle.
Upper trace – tension applied to detached m. masseter; lower trace – muscle of the opposite side. Extension of muscle by load: a) 20 g, b) 100 g.

Experiment on cat aged 6 days. Humps in the line due to movement of electrodes at attachment and removal of load.

in which the masseter muscle was partially separated from the upper jaw and was indirectly stretched by tension applied to its separated distal end, it was shown that reflexes occurred less constantly. Also they differed from the corresponding reflexes of muscles with intact connections by being poorly maintained and rapidly extinguished. It is probable that this is due not only to the trauma associated with the separation of the muscles from the bones, but also the exclusion of other reinforcing "innate" reflexes which occur in stretching the jaw muscles through movements of the jaw.

For comparison we give the electromyograms from experiments on kittens all approximately 5-6 days old. While a tension of the undetached muscle from loads up to 150 g (Fig. 2) was able to produce a well-maintained reflex, inhibition developed very much more quickly on stretching individual muscles (Fig. 3). In stretching a detached muscle with a load of 20 g, the amplitude of the electrical potentials increased from 25-30 to 30-40 microvolts. A 50 g load caused no diminution of the action potentials, but caused a decrease in discharge rate. A load of 100 g not only reduced the rate but also reduced the amplitude of the potentials to less than one half of their original value.

C. Irradiation of proprioceptor excitation. Excitation occurring in kittens on stretching the jaw muscles spreads very readily to neighboring skeletal muscles and to the respiratory center. The younger the kitten, the smaller are the loads required to produce this irradiation. In a kitten 2 hours after birth a tension of 20 g applied to the masseter muscle caused an increase in the tonic muscle tension of the unstretched digastric. A greater tension on the masseter caused an increase in respiration which was visible to the naked eye. The increased excitation of the respiratory center led in turn to irradiation on to the nuclei of the principal and the accessory muscles of mastication. This caused an increase of the inhibitory processes in the stretched muscle and an increase in the excitation of the centers of the unstretched muscles. This explains the increase in electrical activity in the digastric, and the simultaneous reduction in the masseter (see Fig. 1).

Thus the present investigation confirms that the jaw muscles are functional at birth. This is shown by the tonic excitation of the masseter muscle at rest, and by the stretch reflex occurring a few hours after birth.

It must be supposed that the development of proprioception in the masseter is one of the necessary conditions for the development of the complex coordinated act of sucking.

From these experiments we conclude that the masseter muscle in kittens is maintained in a state of tonic excitation from the first hours after birth. The maintained muscular tension is greater during the time of suckling than later on, and is associated with the dominant influence of nutritional movements.

The jaw muscles in 2 hour old kittens show stretch reflexes. The proprioceptor stimulation involved in these reflexes gives rise to some irradiation in the central nervous system.

SUMMARY

The tonus and proprioceptive reflexes of extension of muscles of mastication were studied in experiments on kittens with the aid of the electrophysiological method. It was established that the muscles of mastication show electric activity from the very first hour after the birth of kittens. Broad irradiation and low stability are the specific features of the proprioceptive reflexes which were under investigation.

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