PRESYNAPTIC INHIBITION AND DORSAL ROOT POTENTIALS IN CATS WITH EXPERIMENTAL THYROTOXICOSIS

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A marked decrease in the depth and duration of presynaptic inhibition and a decrease in amplitude of the electrotonic potential take place in cats with experimental thyrotoxicosis. Great difficulty was experienced in obtaining the electrotonic potential in experimental animals during excitation of group 1 fibers.

Data in the literature [1, 4, 15] are concerned, as a rule, purely with the morphological aspects of spinal cord disturbances in thyrotoxicosis. However, the symptomatology of thyrotoxicosis indicates the existence of well marked functional changes in the spinal cord [2-4].

This paper gives data concerning the action of an excess of thyroid hormones on protracted inhibition of the extensor muscles which, in the modern view, is associated with changes in the presynaptic endings of afferent fibers and also its action on dorsal root potentials, reflecting the character of depolarization of afferent endings.

EXPERIMENTAL METHOD

Experiments were carried out on 40 cats weighing 2.5-3.5 kg, with an intact spinal cord. Experimental thyrotoxicosis (19 animals) was produced by feeding the animals with dry thyroid in progressively increasing doses in accordance with a special scheme ensuring loss of 10-20% of the animals' body weight, a mean increase of 30-40% in their heart rate, and an increase in the concentration of iodine bound with the plasma proteins from 4-5 to 18-22 μg%.

Laminectomy was performed under urethane-chloralose anesthesia (400and 35 mg/kg, respectively), and after opening of the dura, the ventral roots L6-S1 were isolated and divided intradurally at the point of their emergence from the spinal canal. Potentials were recorded and nerve and roots stimulated in the usual manner. The threshold of stimulation was determined from the appearance of an action potential of an afferent volley entering the spinal cord. Conditioning stimuli of 1.5 and 3 times the threshold strength (T) were used in the experiments. The conditioning stimuli (single, or consisting of a series of 4 stimuli at 250/sec) preceeded the test stimulus by various time intervals. Monosynaptic responses and electrotronic potentials (ETPs) of the dorsal roots were amplified by means of a type UBP-02 ac amplifier (with time constant of about 300 msec) and recorded from the screen of a dual-beam CRO.

EXPERIMENTAL RESULTS

In the experiments of series I, the development of extinction of maximal monosynaptic responses of motoneurons belonging to the nerve to the gastrocnemius muscle (G) with time, under the influence of conditioning volleys arriving along fibers of group 1a from the deep peroneal nerve (PP), was investigated. Tests were carried out with intervals of 50-700 msec or more between the conditioning and test stimuli.

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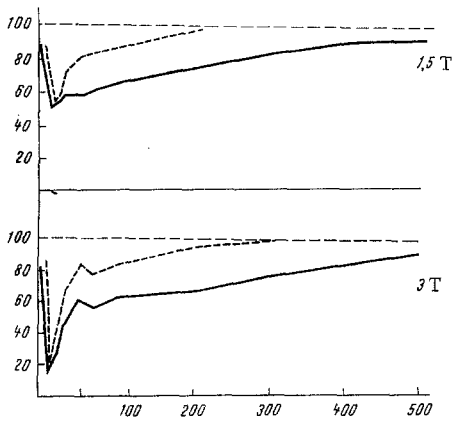

Fig. 1

Fig. 2

Fig. 1. Integral curves showing course of presynaptic inhibition in control animals (continuous line) and animals with experimental thyrotoxicosis (broken line). Changes in amplitude of monosynaptic responses in G under the influence of conditioning volleys in fibers of PP evoked by stimuli of 1.5 and 3 T. Abscissa, time between conditioning and test stimuli (in msec); ordinate, amplitudes of monosynaptic responses in G (in percent of control).

Fig. 2. Dorsal root potentials in control animals (a) and animals with experimental thyrotoxicosis (b). EPT evoked by stimulation of PP at strength of 1.5 T (upper curves) and 3 T (lower curves).

Stimulation of PP at a strength of 1.5 T in healthy animals evoked marked depression of monosynaptic responses in G, which gradually diminished; the amplitude of the test response in G reached its initial level by about 600 msec. Increasing the strength of stimulation to 3 T (stimuli of maximal intensity for group 1 fibers) and application of series of pulses considerably deepened inhibition and increased its duration, reaching 700 msec or more.

In animals with thyrotoxicosis of 3-4 weeks' duration, a marked decrease in the inhibitory effect of PP on monosynaptic responses in G was found. This weakening of the inhibitory action reached a statistically significant level ($P < 0.05$) when the interval between conditioning and test stimuli was 50 msec, and thereafter it continued to increase. The decrease in depth of inhibition was accompanied by a shortening of its duration, to 200 msec for a strength of 1.5 T and 300 msec for a strength of 3 T (Fig. 1).

In experimental thyrotoxicosis a decrease is thus observed in the depth and duration of the late, prolonged inhibition of extensor muscles, which is regarded as presynaptic in origin [6].

The development of this type of inhibition is associated with depolarization of group 1a afferents [6, 8, 10]. The next step was therefore to investigate whether depolarization of primary afferent endings is modified in experimental thyrotoxicosis.

Stimulation of the dorsal root or nerve is known to lead to depolarization of afferent endings spreading electrotonically along dorsal root fibers [6, 7]. Although some workers have found no connection between ETPs of dorsal roots and the depth of presynaptic inhibition, most investigators consider that some correlation exists between these phenomena [6, 8-13]. In the experiments of series II a comparative investigation was accordingly made of the magnitude and duration of ETPs in control and experimental animals.

ETPs were evoked by stimulation of PP at strengths of 1.5 and 3 T for group 1a fibers, and were recorded in a bundle of fibers isolated from the dorsal root of L7. In the animals of the control group the ETP reached an amplitude of 55 ± 6.3 and 101 ± 4.2 μV for strengths of stimulation of 1.5 and 3 T, respectively, and its duration was 106 ± 3.7 and 107 ± 4.2 msec, respectively (Fig. 2). The short duration was evidently associated with the low time constant of the instrument used to amplify biopotentials. With a further increase in the strength of stimulation (to 5 T) only a negligible increase took place in the amplitude and duration of the ETPs.

In animals with experimental thyrotoxicosis a decrease in amplitude of the dorsal root potentials to 63 ± 7.5 μV was observed for a strength of stimulation of 3 T ($P < 0.001$). In the case of stimulation at 1.5 T, the ETP amplitude was 40 ± 12 μV. In this case the difference from the control was not statistically significant ($0.5 > P > 0.2$).

In animals with thyrotoxicosis, a strength of stimulation of 1.5 T was frequently insufficient to evoke an ETP. During analysis of the material, the method of comparison of two alternative distributions was used in conjunction with Fisher's criterion for 2×2 tables. The results showed that it is much more difficult to obtain an ETP with a strength of stimulation of 1.5 T in animals with experimental thyrotoxicosis than in the control group ($P < 0.02$). An increase in the strength of stimulation of PP to 3 T increased the possibility of obtaining an ETP in the experimental group of animals.

Investigations in the author's laboratory [5] and data obtained by other workers [14] have shown that the initial level of membrane polarization of excitable structures is reduced in thyrotoxicosis. This may explain the difficulty in obtaining an ETP using a strength of 1.5 T, and the decrease in amplitude of the recorded potential in the experimental animals.

The duration of the ETP in animals with experimental thyrotoxicosis, stimulated at strengths of 1.5 and 3 T, was 96 ± 5.2 and 101 ± 1.4 msec, respectively, suggesting a tendency toward shortening of the ETP duration.

Hence, in cats with experimental thyrotoxicosis, besides a decrease in the depth and duration of inhibition of presynaptic type, there is also a decrease in amplitude of the dorsal root ETP. Changes in the course of these two phenomena are evidently due to weakening of the depolarizing action of group 1 fibers on endings of afferent fibers.

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