INFLUENCE OF INHIBITORY AND FACILITATORY STRUCTURES OF THE MEDULLA ON SEGMENTAL REFLEXES IN EXPERIMENTAL THYROTOXICOSIS

M. N. Aliev and G. A. Gaidina

UDC 616.441-008.61-092.9-07:616.832-009.81-072.7

Facilitation and inhibition of monosynaptic reflexes (flexor and extensor) in response to stimulation of the reticular formations of the medulla (gigantocellular, parvocellular nuclei, nuclei of the raphe and vestibular complex) were investigated in normal and hyperthyroid cats anesthetized with pentobarbital and chloralose. The position of the stimulating electrodes was verified in serial histological sections. Comparison of the temporal course of suprasegmental influences in the control and experimental animals (receiving thyroid extract for two weeks in increasing doses from 0.4 g to 5.6 g) showed definite weakening of both inhibitory and facilitatory influences and also reversal of the descending effects. It is concluded that an excess of thyroid hormones changes the modulating effect of supraspinal structures on spinal reflex activity.

All types of segmental inhibition of spinal reflexes are disturbed in thyrotoxicosis [1]. The state of suprasegmental regulation of the spinal centers when the thyroid hormone level in the body is elevated has not hitherto been studied. Nevertheless the information could be important in the explanation of the pathogenesis of the motor disorders in diseases of the thyroid gland.

The object of the present investigation was to study the changes in descending influences of certain medullary structures giving inhibitory and facilitatory effects on the spinal reflex apparatus, in experimental thyrotoxicosis.

EXPERIMENTAL METHOD

Cats were anesthetized with pentobarbital and chloralose (15 and 10 mg/kg, respectively, intraperitoneally). Action potentials were recorded from the ventral roots of L_7 and S_1 in response to stimulation of flexor and extensor muscular nerves (deep peroneal and gastrocnemius). Unipolar stimulation with square pulses (five pulses, 500/sec) was applied to the structures of the medulla through microelectrodes (tip 5-10 μ in diameter). The amplitude of stimulation at which the initial phase of the short-latency (4-5 msec) action potential appeared in the ventral root was conventionally regarded as the threshold. The strength of the stimulation used in the experiments was 1.25 times the threshold. The stimulating electrodes were introduced into the corresponding structures in accordance with the coordinates of Szentagothai's atlas. The correct positioning of the electrodes was verified after each experiment by electrical coagulation followed by fixation of the brain and staining of the sections by Nissl's method.

A group of control animals (18 cats) and another of animals with thyrotoxicosis (15 cats) were investigated. Thyroid extract was given daily in increasing doses from 0.4 to 6.0 g for two weeks. During this period the protein-bound iodine concentration in the blood plasma of the animals with thyrotoxicosis rose

Laboratory of Pathological Physiology, Institute of Experimental Endocrinology and Hormone Chemistry, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR N. A. Yudaev.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 75, No. 3, pp. 42-45, March, 1973. Original article submitted May 29, 1972.

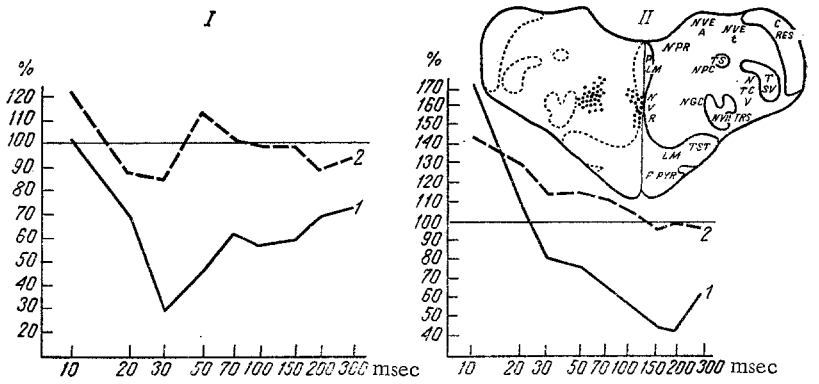

Fig. 1. Temporal course of suprasegmental inhibition induced by stimulation of gigantocellular nucleus on monosynaptic reflexes in control animals (1) and animals with thyrotoxicosis (2). I) Extensor; II) flexor monosynaptic reflexes. Abscissa, interval (in msec) between last stimulus of conditioning stimulation of gigantocellular nucleus and testing stimulus. Ordinate, amplitudes of monosynaptic reflexes (in % of initial value). Each curve represents averaged data obtained in cats of control and experimental groups (7-10 observations).

from 3-4 μg% to 18-20 μg% and the heart rate rose from 100-120 to 180-200/min. A tendency for the weight to diminish was observed.

EXPERIMENTAL RESULTS

Reticular structures with an inhibitory effect on monosynaptic reflexes (the region of the gigantocellular nucleus and nucleus of the raphe) in the control animals led to prolonged inhibition of monosynaptic reflexes (more than 300 msec). The effect observed was bilateral, and flexor reflexes were inhibited with a lower threshold strength of stimulation than extensor. The maximal depth of inhibition for both reflexes was about equal and corresponded to the period from 20 to 70 msec. In most experiments inhibition of the extensor reflexes was characterized by a second phase of inhibition with a maximum in the interval of 150 msec. The prolonged temporal course of the inhibitory effect observed in these experiments evidently reflected reticulo-spinal influences on motoneurons through an interneuron apparatus (in particular, through the interneurons belonging to the system of afferents of the flexor reflex described by several investigators [2, 5]).

In the animals with thyrotoxicosis the threshold of stimulation of the reticular formation studied was increased. Against this background the descending inhibitory effects were considerably weakened (Fig. 1), and in some cases (in response to stimulation of the region of the gigantocellular nucleus) this was accompanied by inversion into a facilitatory response. The most significant differences ($P < 0.01$) in the temporal course of inhibition in the animals of the control and experimental groups were observed for the earlier phase of inhibition.

Later investigations showed that in thyrotoxicosis the facilitatory suprasegmental influences also are changed. In the control animals, stimulation of the facilitatory zones of the medulla (parvocellular nucleus, nuclei of the vestibular complex) led to facilitation lasting up to 100-150 msec, with a maximum in the interval from 10 to 70 msec. Very weak facilitation of reflex responses occurred in the animals with thyrotoxicosis and the extensor reflexes were actually slightly inhibited (Fig. 2). Just as during the investigation of inhibitory effects, the differences in the course of the facilitatory reactions in the control cats and cats with thyrotoxicosis were statistically significant.

These experiments showed that in thyrotoxicosis the excitability of the reticular structures of the medulla, with both facilitatory and inhibitory actions on motoneurons, is reduced. Descending influences on the monosynaptic reflex arc are weakened or even abolished. Assuming that descending control from bulbar formations is the regulator of the afferent flow from the periphery to motoneurons [3], the weakening of regulation must evidently lead to reorganization of the function of the spinal segmental apparatus. As a

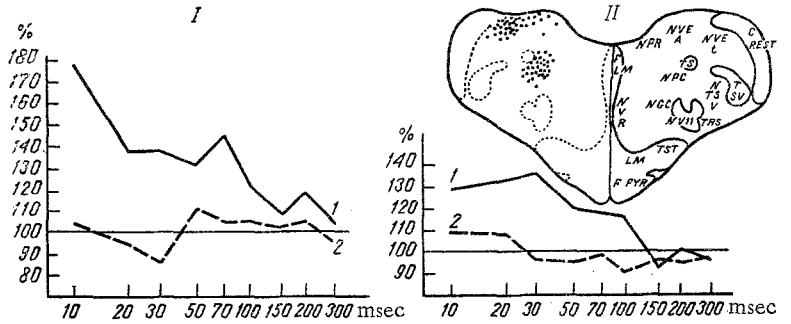

Fig. 2. Temporal course of suprasegmental facilitation induced by stimulation of parvocellular nucleus on monosynaptic reflexes of control animals (1) and animals with thyrotoxicosis (2): I) extensor; II) flexor monosynaptic reflexes. Abscissa, intervals (in msec) between last stimulus of conditioning stimulation of parvocellular nucleus and testing stimulation. Ordinate, amplitudes of monosynaptic reflexes (in % of original value). Each curve represents averaged data obtained in cats of control and experimental groups (7-9 observations).

result of this, modulation of effects recorded at the spinal level may occur: not only weakening, but even inversion of facilitatory and inhibitory influences. In animals with thyrotoxicosis, the early phase of the inhibitory influences is most severely affected. A similar action is observed when the character of the suprasegmental inhibition is investigated after administration of tetanus toxin [4].

In thyrotoxicosis it is evident that not only the activity of reflex spinal mechanisms is disturbed, as the writers have shown previously [1], but also some forms of suprasegmental control.

LITERATURE CITED

1. L. M. Gol'ber, G. A. Gaidina, and V. Ya. Ignatkov, Dokl. Akad. Nauk SSSR, 196, No. 4, 987 (1971).
2. P. G. Kostyuk, Neirofiziologiya, No. 1, 189 (1970).
3. P. G. Kostyuk, in: Mechanisms of Descending Control of Spinal Cord Activity [in Russian], Leningrad (1971), p. 28.
4. G. N. Kryzhanovskii, F. D. Sheikhon, and R. I. Igon'kina, in: Mechanisms of Descending Control of Spinal Cord Activity [in Russian], Leningrad (1971), p. 192.
5. J. Engberg, A. Lundberg, and R. W. Ryall, J. Physiol. (London), 194, 201 (1968).