TONIC INHIBITORY INFLUENCE OF THE BRAIN ON SPINAL INTERNEURONS IN CATS

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The functional state of spinal interneurons involved in the transmission of sensory information largely depends on the descending inhibitory influence of supraspinal structures. The most marked changes in interneuronal excitability are observed during stimulation of the central gray matter, the nucleus magnus raphe, and other medical nuclei of the brain-stem reticular formation [3-6, 8]. Their influence is reflected in modulation, in the spinal cord, of signals arriving from nociceptive receptors and receptors of other modalities. This influence is tonic in character, as is shown by the increase in excitability of interneurons during cooling of a higher level of the spinal cord [7].

The aim of this investigation was to discover how the excitability of spinal interneurons is changed when connections between the cerebral hemispheres and lower brain structures are disturbed.

EXPERIMENTAL METHOD

Experiments were carried out on cats anesthetized with pentobarbital sodium (35 mg/kg). Laminectomy was performed in the region of the lumbosacral enlargement of the spinal cord, the dura mater was divided, and the right and left medial popliteal nerves were dissected. The exposed tissues were flooded with warm mineral oil.

Spinal interneurons were activated by stimulation of the medial popliteal nerve with an ÉSU-2 electronic stimulator. The amplitude of the N_1-component of the dorsal cord potential (DCP), reflecting excitation of spinal interneurons activated monosynaptically by cutaneous and muscular afferents, was measured. Potentials were recorded from the dorsal surface of the spinal cord in the region of segments L7-S1 by means of a ball electrode. The reference electrode was secured to the vertebral column. The DCP were amplified and recorded by means of the UBF4-03 amplifier, S1-18 cathode ray oscilloscope, and FOR-1 camera.

The tonic influence of the cerebral hemispheres in spinal interneurons was tested by means of a series of operations. Unilateral division of the basic pedunculi or tegmentum mesencephali on the boundary with the diencephalon was carried out [1], together with the unilateral removal of the sensomotor cortex. The amplitudes of the N_1 component of DCP evoked by stimulation of the ipsilateral and contralateral medial popliteal nerves relative to the side of the operation were compared. By moving the recording electrode across the dorsal surface of the spinal cord symmetrical points were located at which stimulation of the ipsilateral nerve evoked responses of maximal amplitude, but stimulation of the contralateral nerve evoked responses of minimal amplitude. Different strengths of stimulation, expressed as thresholds of excitability of afferent fibers, were used. The threshold was judged by the appearance of presynaptic spike of the DCP. The parameter of excitability of the spinal interneurons was the slope of the curves reflecting amplitude of the N_1 component of the DCP as a function of strength of stimulation. Completeness of the brain sections was verified in brain preparations stained by Nissl's method.

EXPERIMENTAL RESULTS

Unilateral division of the tegmentum mesencephali caused changes in excitability of the interneurons which generate the N_1 component of the DCP. In the experiments of series I the test parameters were compared before division of the tegmentum mesencephali and immediately thereafter. Traces recorded in one experiment and averaged results of the whole series are

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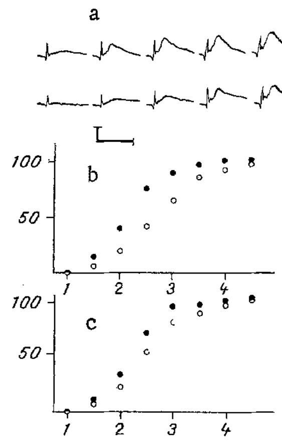

Fig. 1

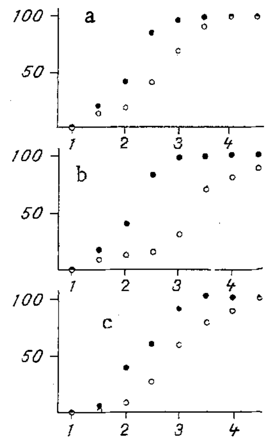

Fig. 2

Fig. 1. Time course of interneuronal activity during an increase in the intensity of stimulation before and after unilateral division of the tegmentum mesencephali. a) N_1 component of DCP evoked by stimulation of contralateral nerve before (bottom row) and after division (top row). Strength of stimulation from left to right: 2, 2.5, 3, 3.5, and 4 thresholds. Calibration 1 mV, 5 msec. b) Amplitude of N_1 component of DCP as a function of strength of stimulation of contralateral nerve before (empty circles) and after division (filled circles). Abscissa, strength of stimulation (in thresholds). Ordinate, amplitude of response (in % of maximal). c) The same, for ipsilateral nerve.

Fig. 2. Asymmetry of interneuronal activity after unilateral division of tegmentum mesencephali (a), division of basis pednuclei (b), and removal of sensomotor cortex (c). Abscissa, strength of stimulation (in thresholds); ordinate, amplitude of N_1 component of DCP (in % of maximal).

given in Fig. 1. An increase in strength of stimulation of the contralateral nerve caused the more rapid growth of amplitude of the N_1 component after the operation than before it (Fig. 1a). This led to an increase in the steepness of slope of the curve reflecting the magnitude of the response of the function of intensity of stimulation (Fig. 1b). In the case of stimulation corresponding to 1.5, 2, and 2.5 thresholds of the afferent fibers, the difference between the relative value of the N_1 component of DCP before and after the operation was statistically significant ($P < 0.05$). In some experiments a difference of this sort was observed in response to stimulation of the ipsilateral nerve also, but on average it was smaller (Fig. 1c).

Changes in excitability of interneurons occurred mainly on the side of the spinal cord contralateral to the side of division of the tegmentum. In this series, this particular operation was performed 6-7 days before the experiment. In all experiments, with stimulation of submaximal strength, considerable asymmetry of the relative value of the N_1 component of the DCP evoked by stimulation of the contra- and ipsilateral medial popliteal nerves was observed. The results of one of these experiments are given in Fig. 2a; they show a more rapid increase in amplitude of the response with an increase in the strength of stimulation of the contralateral than of the ipsilateral nerve.

In two other series of experiments, the effect of preliminary unilateral division of the basis pedunculi and removal of the sensomotor cortex was investigated in the same way. In both series of experiments asymmetry of interneuronal activity also was discovered. The slope of the curves reflecting dependence of the amplitude of the N_1 component of the DCP on the strength of stimulation was found to be steeper for the contralateral than for the ipsilateral nerve (Fig. 2b, c).

This increase in steepness of the slope of the curves is evidence of increased excitability of the spinal interneurons after division of pathways connecting the cerebral hemispheres with the brain stem. It can be concluded from the experimental results that the cerebral hemispheres exert tonic inhibitory control over interneuronal activity in the spinal cord. This control is disturbed by removal of the sensomotor cortex, from which the pyramidal system arises, and after division of the basis pedunculi, through which its fibers run. However, the same effect also arises after division of the tegmentum mesencephali, through which run fibers from the cortes and tegmental nuclei to the red nucleus, which belongs to the extrapyramidal system. A similar effect was found during an investigation of the effect of division of the tegmentum on conduction of impulses in the nuclei of the dorsal columns [2]. The inhibitory action of the cerebral hemispheres on spinal interneurons is thus linked with functionally different descending systems. It can be tentatively suggested that this action is realized through nuclei of the brain-stem teticular formation, on which fibers from different descending pathways converge widely.

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EFFECT OF ELECTROACUPUNCTURE ON CHANGES IN FIRING PATTERN OF CORTICAL NEURONS OF THE SECOND SOMATOSENSORY AREA

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Depression of nociceptive sensitivity during reflex therapy is associated with inhibition of condution of nociceptive impulses in afferent pathways of the CNS due to activation of the brain antinociceptive system [2, 5, 7]. An important role in the development of the analgesic affect arising after electroacupuncture (EAP) is played by the second somatosensory area of the cortex (area SII), which is responsible for modulating activity of the brain antinociceptive system [2, 5]. It has also been shown that the amplitude of evoked potentials in region SII after EAP in response to nociceptive stimulation is reduced, whereas during nonnociceptive stimulation it is increased [6]. These results suggested that EAP has opposite effects on nociceptive and non-nociceptive neurons in area SII.

To confirm this hypothesis directly it was decided to study changes in spontaneous and evoked single unit activity in area SII in response to nociceptive and nonnociceptive stimulation after EAP.

EXPERIMENTAL METHOD

Acute experiments were carried out on 32 adult cats anesthetized beforehand with hexobarbital (25-30 mg/kg, interperitoneally), immobolized sith succinylcholine, and artificial-

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