MONOSYNAPTIC EXCITATORY POSTSYNAPTIC POTENTIALS IN THORACIC MOTONEURONS UNDER RETICULOSPINAL INFLUENCES

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We studied synaptic processes in motoneurons of thoracic segments (TIX–TXI) evoked by stimulation of the medial area of the giant-cell reticular nucleus in decerebrated cats. Monosynaptic EPSP were recorded in the majority of investigated motoneurons upon activation of the most rapidly conducting reticulospinal fibers. In some cells, such monosynaptic EPSP were accompanied by late EPSP or IPSP. Amplitude of monosynaptic EPSP attained 5 mV, but this value usually was insufficient for development of an action potential. Upon summation of single monosynaptic EPSP, the membrane potential reached the critical level and an action potential arose in the motoneuron. The efficiency of summary processes evoked by stimulation of the reticular formation exceeded the intensity of synaptic processes that arise in thoracic motoneurons on stimulating the nucleus of Deiters. Functional characteristics of reticular and vestibular monosynaptic EPSP are discussed in the work.

The activity of spinal motoneurons is controlled by several descending systems that differ with respect to their neuron organization. Corticospinal and rubrospinal control motoneuron activity in cats is effected through the medium of spinal interneurons [1, 3, 12, 13]. The descending fibers that ensure transmission of monosynaptic influences originate either from neurons of the reticular formation of the medulla oblongata [16, 24] or from the vestibular nuclei [18, 20]. Degenerated fibers of these two descending systems are found in the gray matter of the spinal cord in the medial part of lamina VII and in lamina VIII according to Rexed [19].

Reticulospinal fibers exert monosynaptic excitatory action on flexor motoneurons of the neck muscles and muscles of the anterior and posterior extremities [26]. Fibers of the vestibulospinal tract monosynaptically activate for the most part extensor motoneurons of the neck muscles and muscles of the posterior extremities [26]. Monosynaptic inhibitory postsynaptic potentials (IPSP) evoked by vestibulospinal impulses have been discovered exclusively in extensor motoneurons of the upper cervical segments of the spinal cord [27].

Features of descending control exerted by supraspinal systems on the activity of thoracic segment motoneurons have thus far been virtually ignored. The purpose of the research was to study synaptic processes in thoracic motoneurons under descending influences from the medial reticular formation and compare them with processes evoked by stimulation of the lateral vestibular nucleus.

EXPERIMENTAL METHOD

Experiments were carried out on cats decerebrated under ether anesthesia by making an intercollicular crosscut of the brain stem. The spinal cord was laid bare at the level of thoracic segments IX–XII. Respiratory movements of the rib cage and associated vibrations of the spinal cord were prevented by insertion of a two-way pneumothorax. The animals were immobilized with an injection of listenone (0.5 mg/kg weight), and breathing was sustained by artificial means.

Fig. 1. Impulse activity of a single reticulospinal fiber.

a) Responses evoked by stimulation of the giant-cell reticular nucleus (RF) with a different number of stimuli; b) absence of activation of the fiber by impulses in peripheral afferents. These and subsequent oscillograms were obtained by superposing several scans of the beam. The upper oscillogram represents potentials of the dorsal surface of the spinal cord; the lower one represents electrical reactions of individual cells. Numbers indicate the strength of stimulation in relation to threshold.

Electrical activity of thoracic motoneurons was recorded in segments TIX–TXI with the aid of glass micropipettes filled with 0.6 M K₂SO₄ solution or 2.7 M KCl solution (resistance of the microelectrodes was 5–15 MΩ).

Cutaneous and deep muscle branches of the 9th, 10th, 11th, and 12th intercostal nerves (n. m. intercostalis) and the greater splanchnic nerve (n. splanchnicus major) were cut and placed on the stimulating electrodes. Motoneurons were identified on the basis of their antidromic excitation during stimulation of nerves of the expiratory muscles [6].

Access to the medulla oblongata was gained by removing the occipital bone and sucking away part of the cerebellum. The medial reticular formation and lateral vestibular nuclei were stimulated with single square pulses of various amplitude (1–10 V at current strength of 30–300 μA) or a series of such stimuli with the aid of bipolar concentric electrodes having an interelectrode distance of up to 300 μ. Intensity of stimulation was also regulated on the basis of size of the descending wave recorded from the dorsal surface of the spinal cord at the level of thoracic segments IX–XI.

Electrodes were stereotaxically inserted in the area of the lateral vestibular nucleus (P-7-8; L-4; H-6) and into the medial sectors of the giant-cell reticular nucleus (P-10; L-0.5–0.8; H-3) of the side investigated [22]. At the end of the experiment, the stimulated structures were destroyed electrolytically and position of the marker determined by the histological method. We used stimulation of the ipsilateral ventral funiculi of the spinal cord at the level of cervical segment IV to study the electrophysiological characteristics of fibers of the reticulospinal and vestibulospinal tracts.

RESULTS

Electrical stimulation in the medial area of the giant-cell nucleus of the reticular formation evokes an intense descending wave that can be recorded from the dorsal surface of the spinal cord (Fig. 1a, upper oscillogram). Reticulospinal fibers of the ventral funiculi situated at a depth of 3.0–3.8 mm take part in its formation (Fig. 1a, lower oscillogram). The latent period of the descending wave and action potentials in separate reticulospinal fibers at the level of thoracic segment XI comprised 1.6–1.9 msec. The latent period of responses of the same fibers during stimulation of the ipsilateral ventral funiculus in the area of CIV equaled 1.2–1.5 msec. The rate of excitation conduction in the reticulospinal fibers attained 130 m/sec.

Stimulation of deep branches of the intercostal nerves led to the emergence of excitatory postsynaptic potentials in thoracic motoneurons (Fig. 2). Short-latent EPSP of simple form developed when nerves of the investigated and neighboring segments were stimulated at threshold strength. The central stop of these responses comprised 0.6–0.8 msec, and this enables us to regard them as monosynaptic EPSP.

Identification