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REACTIONS OF RETICULOSPINAL NEURONS DURING STIMULATION OF THE VESTIBULAR NERVE AND SPINAL CORD

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Abstract. Neurons of the medial reticular formation (MRF) in response to stimulation of the anterior branch of the vestibular nerve, as well as the cervical and lumbar spinal cord, were studied using the intracellular potential abduction method on a preparation of perfused frog brain. Antidromic, mono- and polysynaptic action potentials (APs) were recorded in response to vestibular nerve stimulation.
Keywords: medial reticular formation, spinal cord.

INTRODUCTION

The motor activity of the body is the result of a complex interaction between the motor structures of the brain and spinal cord. Reticulospinal neurons, located between the supraspinal structures and the spinal cord, play a key integrative role in the integration-execution interaction. Many complex centers are located in the reticular formation. Certain areas of the medulla oblongata influence motor neurons in the spinal cord. These bulbar neurons are influenced by overlying brain regions. In the ventrolateral part of the reticular formation of the medulla oblongata, a group of cells was identified that has an inhibitory effect on spinal reflexes. Cells of the dorsal part of the reticular formation ensure the implementation of spinal reflexes [1]. The reticulospinal tract is the most ancient cerebrospinal system. In mammals, it has been demonstrated that the MRF receives inputs from the vestibular system. Morphological studies revealed the presence of fibers starting in the vestibular nucleus and ending in the reticular formation (RF).

MATERIALS AND METHODS

In the evolutionary aspect, amphibians are most suitable for studying the processes of controlling the movements of the body, in connection with the development of a four-limbed body and with a partial or complete transition to land [3]. The motor structures of amphibians are the least differentiated. However, their vestibular nuclei integrate signals from various parts of the nervous system and influence the motor and autonomic centers. Together with the RF and the cerebellum, they provide regulation of body balance, orientation in three-dimensional space and modification of muscle tone. Under natural conditions, RF neurons can also be activated by stimulation of vestibular receptors [2].

The studies were carried out on a perfused preparation of 96 lake frogs (Rana ridibunda) of both sexes. The animals were anesthetized with a solution of MS-222 (0.2 mg/g). Electrical stimulation of the anterior branch of the VIII nerve was carried out using a suction electrode. Bipolar tungsten electrodes were used to stimulate the cervical and lumbar spinal cord. Electrical stimulation of the above structures was carried out with single direct current shocks (0.1-0.2 ms: 0.05-0.4 mA). Intracellular potential removal was carried out with ground glass microelectrodes filled with a 2 M solution of potassium citrate. Computer data analysis was carried out using NiDiadem and Origin 8.5 programs.

RESULTS AND DISCUSSION

The intracellular activity of 250 reticular neurons was recorded. When stimulating the anterior branch of the VIII nerve, antidromic action potentials (APs) arose in 20 reticular neurons with a short, fixed latency period of 0.51-1.05 ms (average 0.78 ± 0.18 ms, n = 20) at different stimulation intensities. A minimal decrease in stimulation intensity led to the disappearance of APs without signs of the emergence of a postsynaptic potential. Based on the results obtained, it can be assumed that the vestibular nerve may also contain axons of reticular neurons.

Stimulation of the vestibular nerve in 230 MRF neurons evoked chemically transmitted excitatory postsynaptic potentials (EPSPs). The EPSP latency period in 174 neurons was 1.1-3.08 ms (on average 2.22±0.47 ms, n=174). The EPSP data had a fast ascending phase of 1.36-4.83 ms (average 2.91±0.0.76 ms, n=69). The total duration of the EPSP ranged from 5.63-13.4 ms (on average 9.93±2.3 ms, n=67). With increasing stimulation, their amplitude gradually increased and reached 0.3-2.53 mV (avg. 1.08±0.3 mV, n=63). A further increase in the strength of stimulation led to the emergence of APs based on EPSPs with a latent period of 1.83–6.73 ms (on average 3.92 ± 1.13 ms, n = 148). The mentioned time parameters practically did not change at different stimulation intensities, which gave grounds to classify these EPSPs as monosynaptic. Morphological studies on the pond frog (Rana esculenta) and lampreys have shown an abundance of vestibular afferents in the MRF [4], which proves the likelihood of monosynaptic activation of reticulospinal neurons by vestibular afferents.

In 56 MRF neurons, recorded EPSPs were characterized by a longer and more unstable latency period ranging from 3.15 to 6.82 ms (average 4.1 ± 0.77 ms; n = 56) depending on the intensity of stimulation. Their ascending phase was in the range of 1.36-6.34 ms (average 3.22±0.98 ms; n=20), the total duration was 4.98-17.54 ms (average 11.03±2.33 ms; n=23). The EPSP amplitude also increased and reached 0.41-2.8 mV (on average 1.18±0.54 mV; n=15). A further increase in stimulation intensity led to the emergence of APs with a latent period of 4.26–10.31 ms (average 6.43 ± 1.28 ms; n = 39). The above-mentioned temporal characteristics, their instability and dependence on the intensity of stimulation, indicate a polysynaptic origin [2].

Upon stimulation of the spinal cord, antidromic action potentials occurred in 228 reticular neurons responding orthodromically to stimulation of the vestibular nerve. They had the same features as antidromic responses to vestibular stimulation. Cells responding to stimulation of the cervical spinal cord were identified as C-neurons. They projected to the cervical and thoracic spinal cord. The latency period of these APs was in the range of 0.37-1.66 ms (average 0.7±0.22 ms; n=105). The cells activated by stimulation of the lumbar region are L-neurons. The latter were projected to the lumbosacral parts of the spinal cord. The latent period of these APs was 0.51-1.8 ms (average 1.05±0.3 ms; n=123) [4].

CONCLUSION

It has been proven that reticulospinal neurons are scattered in small groups throughout the MRF and do not form a nucleus [8]. The best effect of potential removal was observed when a microelectrode was inserted into the bottom of the fourth ventricle at 1.5-2 mm caudal to the entrance of the vestibular nerve, 200-500 µm lateral to the midline and at a depth of 500-1000 µm from the dorsal surface. Axons of reticulospinal neurons of amphibians as part of the ventral funiculi monosynaptically contact motor neurons of the cervical and lumbar enlargements. In cats, it was shown that 81 of 191 reticulospinal axons terminated between Ce2 and Th5, 21/49 terminated between Th5 and Lu5, and 34/61 reached Lu5 [9]. It has been proven that the recorded monosynaptic reactions are of an excitatory nature.

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