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Short Communication

Neural Organization of the Neostriatum

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Abstract

The nuclei that make up the basal ganglia differ in structure, which to some extent determines the peculiarities of the physiological processes occurring in them. Only the caudate nucleus and the shell, which, as mentioned represent above, two parts of a single subcortical formation, the neostriatum, show complete similarity in neural organization.

Keywords: neural organization; neostriatum; nervous system

Introduction

The nuclei that make up the basal ganglia differ in structure, which to some extent determines the peculiarities of the physiological processes occurring in them. Only the caudate nucleus and the shell, which, as mentioned represent above, two parts of a single subcortical formation, the neostriatum, show complete similarity in neural organization [6]. The neostriatum, as the largest subcortical nucleus of the brain has been studied in more detail morphologically and electrophysiologically compared to other basal ganglia. The size of neurons in the caudate nucleus has been reported to vary from 7.5 to 32.5 μm, but more than 90% of the cells are 10- 18 μm . On the basis of the data on the structure of cell bodies, their dendrites and axons, in the neostriatum several types of neurons have been identified. Axons of the majority of neurons end within the neostriatum and only a small number of neurons send their axons outside it. In this regard, one of the features of the structure of the neostriatum is the abundance of internal connections [5-10]. A small damage inside the caudate nucleus causes degeneration of terminals with symmetrical membrane thickenings and flat vesicles, which according to the existing ideas is a sign of inhibitory termination. The insertion neurons of this nucleus have an exclusively inhibitory function. On this ,basis many physiological properties of its neurons, in particular, their low excitability, were explained by the presence of a constant inhibitory influence from the insertion neurons, creating as if some hyperpolarization. However, detailed studies of synapse architectonics and chemical organization of the caudate nucleus indicate the heterogeneity of its interneurons, which suggests a variety of ways of interaction between them [9-11]. This has already been partially confirmed in the study of the activity of pairs of neurons in the caudate nucleus [11]. The neostriatum is considered to be a morphologically homogeneous structure, but a number of authors distinguish it into several fields differing in cytoarchitectonics and synapsearchitectonics. The grouping of neurons of the caudate nucleus into cone-shaped ensembles has been described. The distribution density of neurons in the nucleus is high. The space between the surfaces of the bodies of two often neurons is only a few hundred nanometers, which suggests the possibility of asynaptic interaction between such neurons [5-10]. The microstructures of the caudate nucleus are characterized by a significant number of tangential synapses. Most of them are axodendritic. Axons do not lie parallel to dendrites, but tend to cross dendrites, passing from one to another by the same or different cells. Despite a certain predominance of divergence of terminations, significant numbers convergence is also observed in , especially in the body of the caudate nucleus, where on more than two axon terminals were found one dendrite [2-4]. Another feature of the caudate nucleus is the high density of the neuropil formed by a large number of myelinated and unmyelinated fibers. Majority of this plexus collaterals of short-axon and partially long-axon , make up the cells, as well as incoming afferent fibers. The diameter of unmyelinated fibers is 0.3-0.5 μm or less, and myelinated fibers average 0.6 μm. The speed of conduction of nerve impulses along such fibers is very low. This is probably why, when studying neurons the caudate neurons of discrepancy between the latency nucleus using electrophysiological methods, we often encounter an apparent .periods of monosynaptic activation responses of these neurons on the side of the activation of the monosynaptic activation of of these neurons by afferent inputs. The responses of these neurons to antidromic activation also have large latent periods that can reach 20-30 ms. Large latent periods of the responses of these neurons were observed even with direct stimulation of the nucleus: 11 ms on average when the distance between the points was between the points was withdrawal and stimulus 1.5 mm withdrawal and stimulus and ranged from 5 to 40 ms when the distance not fixed at 1-4 mm [1-5]. Currently, the electrophysiological properties of caudate nucleus neurons have been studied in detail. It has been shown that these neurons have a large membrane potential; its value can reach 76 mV. The EPSPs evoked in the neurons of the caudate nucleus when the nucleus itself, as well as the cortex and medial thalamus were stimulated, slowly increased, had a significant amplitude (15-20 mV and duration 60-100 ms) and only rarely led to the generation of one or two discharges [11-14]. These observations gave reason to call these neurons the most "lazy" in the entire mammalian nervous system and to compare them with immature neurons of the neocortex, as well as to assume the presence of special electrical properties of their membrane. However, these assumptions were not justified. Recent measurements of electrical constants of the membrane of neurons of the caudate nucleus showed that the average values of input resistance and time constant for them are 16.5 megohms and 11.3 ms, respectively. These values are many times higher than the analogous parameters for motoneurons, but insignificantly higher for pyramidal cells of the cerebral cortex. Tailed nucleus neurons have a high membrane potential, but the threshold for synaptic activation is 5.6 mV [14]. It is thought that there may be caudate nucleus neurons only in terms of frequency due to their long (more than 20 ms) relative refractory period. This agrees well with the results obtained in the limitations in PD generation by study of frequency characteristics of caudate nucleus neurons. Increasing the stimulus frequency above 30 imp/s does not cause an increase of the cell discharge frequency. Based on the above, we can conclude that the caudate nucleus is characterized by relatively low lability [16-18]. The neural organization of the pallidum differs from that of the neostriatum. It has been studied most thoroughly in primates. The neurons of the pallidum are overwhelmingly large (35-50 microns), longaxonal, and rarely located in the spaces between bundles of mostly myelinated fibers passing through the nucleus. Particular attention is drawn to the structure of the dendrites of these neurons: long, thick, sparsely branched with sparse spines. In small spindle-shaped neurons it is difficult to trace the boundary between dendrite and soma. The total length of the dendrites of a single neuron can reach 4000 µm, so that the cell surface is insignificant compared to the surface of the dendrites. In contrast to the caudate nucleus, where axon terminals run, crossing the dendrites, in the pale globus, they are oriented parallel to each other, forming longitudinal axodendritic connections, a type of synapse characteristic of cerebellar Purkinje cells [15]. Functionally, such synapses should be very effective, as can be evidenced by the possibility of extracellular registration of TPSPs evoked in these neurons. More often than in the neostriatum, were observed in the pale globusmultiple synapses formed by 6-8 axon terminals. Axodendritic synapses are the predominant type of contacts, although in small axosomatic and axoaxonal synapses also occur numbers [17-22]. Thus, the neural structure of the neostriatum suggests that signal integration occurs in a complex neuronal network with mutual overlap of different afferent inputs carrying these signals. In other structures, the pallidum, for example, characterized by the absence of a pronounced interneuron apparatus, the transformation of afferent influences and their transmission probably occur according to a simpler scheme.

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