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Influence of a Nitric Oxide Donor on Electrical Characteristics of the Premotor Interneurons of Terrestrial Snails

Tatiana Kh. Bogodvid[1,2] · **Vyatcheslav V. Andrianov**[1,3] · **Lyudmila N. Muranova**[1] · **Khalil L. Gainutdinov**[1,3,4]

Abstract It has been found that application of a nitric oxide donor—the sodium nitroprusside—causes the hyperpolarization shift of the membrane potential of the premotor interneurons of defensive behavior of terrestrial snails. It is assumed that the response of a neuron to NO depends on its location in the neural network.

Keywords Nitric oxide · Sodium nitroprusside · Identified neurons · Membrane potentials · Snail

1 Introduction

In the studies devoted to the analysis of the mechanisms of learning and memory, it has been shown that there are membrane (cellular) correlates, which are expressed in increase of neuronal excitability due to the elaboration of conditioned reflexes [1–5]. The parameters, through the changes of which the neuronal excitability is expressed, are the firing frequency, the number of spikes in response to electrical stimulus, and the membrane and threshold potentials. It is shown that there is a direct relationship between the membrane characteristics of the premotor interneurons of defensive behavior and the plastic modifications of the behavior, which illustrates the complex dynamics of the changes of these parameters in learning [6].

The discovery of the ability of mammalian cells to synthesize the nitric oxide free radical (NO) has stimulated significant efforts of researchers to study the role of NO in all the areas of biology and medicine [7–10]. NO-synthesizing neurons were also found in the nervous system of invertebrates, including mollusks [11]. It was found that NO is involved in behavioral programs and in activation of cGMP, more and more data are being accumulated that in the nervous system NO is involved in the development, maturation and aging of the brain, in the processes of learning and memory [10, 12–14]. In the experiments on preparations of terrestrial snails, it is shown that NO donors increase the firing frequency and decrease the latency of spikes in the identified neurons [15].

Therefore, the aim of this work was to study the effects of NO donor on the membrane potential of a premotor interneuron of the snail's defensive behavior.

2 Methods

The terrestrial snails *Helix lucorum*, the nervous system of which is well described, were used for the experiments. Before the experiments, the mollusks were in the active state for at least 2 weeks. The electrical characteristics of the premotor interneurons of the snail's pneumostome closure reflex were analysed [16, 17]. The recordings of the electrical characteristics were carried out using intracellular glass microelectrodes with resistance of 3–10 MoM. The effects of the application of sodium nitroprusside (SNP), a donor of NO (at a concentration of 10^{-4} mol/l), to the solution bathing

✉ Khalil L. Gainutdinov
kh_gainutdinov@mail.ru

1 Institute of Fundamental Medicine and Biology of Kazan Federal University, Kazan, Russia

2 Volga Region State Academy of Physical Culture, Sport and Tourism, Kazan, Russia

3 Zavoisky Physical-Technical Institute of Russian Academy of Sciences, Kazan, Russia

4 Laboratory of Neurobiology of Institute of Fundamental Medicine and Biology of Kazan Federal University, Kazan, Russia

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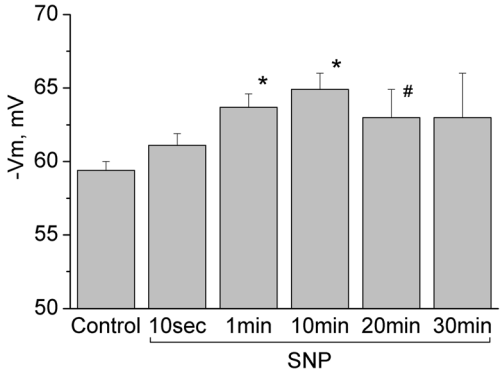

Fig. 1 The membrane potential dynamics (Vm) of the premotor interneurons of the snail's defensive behavior in response to the application of NO donor—sodium nitroprusside (SNP). The *asterisk symbol* indicates the reliable difference ($p < 0.001$) relative to the control group. The *not equal sign* indicates the reliable difference ($p < 0.01$) relative to the control group

the preparation on the membrane potential (Vm) of the premotor interneurons were studied.

The results are reported as mean ± SEM. The Student's *t* test and non-parametric Mann–Whitney tests were used.

3 Results and Discussion

In the experiments, it is found that application of the NO donor SNP at a concentration of 10^{-4} mol/l to the solution bathing the preparation of the isolated nervous system caused an increase of the resting membrane potential of the premotor interneuron by 5.5 mV at the 10th minute, $n = 12$ (Fig. 1). The difference between the experimental and control preparations was significant ($p < 0.001$). Thus, we have demonstrated that NO can cause hyperpolarization of the membrane in certain neurons. At the same time, there is a study demonstrating that NO, on the contrary, causes an increase in neuronal excitability [15]. It seems to us that in these two papers, there is no contradiction: the observed effects depends on the individual properties of nerve cells and functional significance in the neural network.

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