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Modeling of Nerve Impulse Conduction in the Myelinated Nerve Fiber

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ABSTRACT

Myelination of a nerve fiber done by oligodendrocytes or Schwann cells is essential for the correct nervous system function, particularly for the sufficient speed of nerve impulse propagation, which is termed saltatory signal conduction. It is believed that the action potentials in myelinated nerves are only generated at the nodes of Ranvier, this conserves energy and facilitates electrical impulse propagation. The clinical significance of such demyelinating diseases as multiple sclerosis leads to the necessity of studying the characteristics of nerve impulse transmission to elucidate the effects of demyelination on conduction and development of pathological symptoms. Meanwhile, the precise mechanism of the process is still under investigation due to the considerable complexity of direct experimental evaluation, which, nevertheless, can be circumvented by mathematical modeling methods.

The purpose of this study is to model the mechanisms of nerve impulse propagation along a nerve fiber depending on various parameters. A 3D model of the myelinated nerve fiber of a human optic nerve was built using the COMSOL Multiphysics software package, incorporating known geometric characteristics. The transmission of the action potential along it was simulated. Currents of sodium, potassium and chlorine through voltage-dependent and mechanosensitive ion channels were taken into account. The obtained modeling results can clarify the underlying mechanisms of action potential conduction in the nervous system.

Keywords: action potential, mathematical modelling, myelination

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