MODELING OF AMBIENT GLUTAMATE CONCENTRATION MEASUREMENT IN THE MAMMALIAN NERVOUS SYSTEM

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There exists a big discrepancy between two existing methods of measuring the ambient glutamate concentration in the mammalian (human in particular) nervous system. This work focuses on the construction of a mathematical model that describes these techniques and explains the 100-fold difference in their measurements.

Keywords: glutamate, microdialysis, electrophysiology, modeling, diffusion.

A neuron is a unit of the nervous system. It transmits information along itself through action potential, a cross-membrane potential change, and passes signals to other cells through the structure called synapse. This work focuses on chemical synapses that use signaling molecules (neurotransmitters) as signal messengers. One of the most used excitatory neurotransmitter in the central nervous of the human and mammals in general is glutamate. It is directly or indirectly involved in most brain functions. A prolonged overstimulation of the glutamate receptors is harmful for neurons, thus it is important to measure the ambient baseline glutamate concentration for medical purposes as well as for future modeling and studies. Two different methods exists to estimate this value: microdialysis and electrophysiological methods. However, microdialysis measurement turns out to be about 100-fold higher than the electrophysiological measurement.

Microdialysis is an invasive sampling technique that is widely used to measure the concentrations of free analyte in the extracellular fluid. The idea is to insert a microdialysis catheter with semipermeable walls into the tissue. Because of the perfusion, one is able to measure the concentration of the substance of interest after some time when the stable state of the system has been reached. It was suggested that because of the invasiveness of the microdialysis method the glutamate transporters activity could be reduced in a small region adjacent to the dialysis probe, which might lead to the overestimation of the glutamate concentration in the extracellular space.

This work presents a mathematical model of this process constructed under several assumptions in order to investigate the dynamic and the steady state of the glutamate concentration inside the dialysis probe and in a small region nearby. The model is used to provide a possible explanation for the discrepancy of the two mentioned above methods.

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