Astrocytes as an orchestrating force behind blood flow and neuronal activity

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The functioning of the nervous tissue of the cerebral cortex can be governed not only directly through a change in neuronal activity, but also by influencing astrocytic dynamics. Normal activity of the nervous tissue is impossible without maintaining a balance in ion flows, first of all, the release of potassium ions by neurons into the intercellular space and the incoming flow of sodium ions, the absorption of excess potassium ions by astrocytes and blood vessels, and the absorption of a large number of anions by astrocytes. We present a new minimalistic neurogliovascular model that takes into account the influence of astrocytic dynamics on neuronal activity, basing on the synthesis of arachidonic acid derivatives. The model describes IP3-dependent calcium dynamics in the astrocyte, neuronal activity, vascular dynamics, the synthesis of arachidonic acid and its derivatives. The synthesis of the vasodilator metabolites EETs and PGE2 and the vasoconstrictor metabolite 20-HETE is responsible for the bidirectional control of the radius of blood vessels, thereby determining the intensity of blood flow and the functioning of the nervous tissue as a whole. Numerical analysis of the model confirms that it successfully reproduces the effect of arachidonic acid metabolites on neurovascular dynamics. A study of vasodilating and vasoconstrictive scenarios for controlling the activity of the neurogliovascular unit was carried out. This study was supported by the Russian Science Foundation, grant 22-74-00146.