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Mechano-chemical effects accompanying and influencing the diffusion of calcium

We discuss the coupling between chemical and mechanical processes which are accompanying and influencing the diffusion of calcium in biological tissues. In this approach the tissue as a whole, similarly as a single cell, is treated as a visco-elastic medium. The diffusion of calcium is enhanced by the autocatalytic release of calcium from the endoplasmic reticulum, and modified by reactions with diffusing buffers. In addition, the mechanical strain can also influence the release of the cytosolic calcium. As a result, the waves of calcium concentration can be excited by the mechanical as well as by the chemical means. It appears, that in certain cases the stretch activated channels can be responsible for an additional influx of calcium through the cell membrane. This mechanism is greatly influencing the speed of calcium waves. Developing certain asymptotic procedures with respect to the viscosity of the medium as well as with respect to its size (a thin cylinder as a model of a cell and a thin layer of tissue), and finally assuming the fast reaction terms in the equations for buffers, we reduce the full system of equations to a single nonlinear reaction diffusion equation. The dimensionality of this equation corresponds to the dimensionality of the problem (a single space variable for the cell, two space variables for a thin layer of tissue, and three space variables in case of a bulk medium).

References

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