

Computationally Efficient Model for Human Ventricular Epicardial Cells

Niccoló Biasi, Alessandro Tognetti

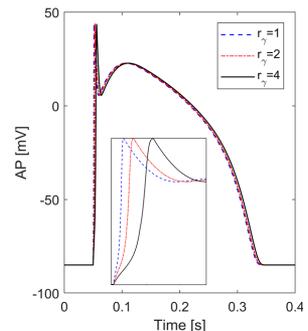
Dipartimento di Ingegneria dell'Informazione, Università di Pisa
Pisa, Italy

Aims: Development of an efficient phenomenological model for ventricular epicardial cells. The model is proposed as a useful tool for large-scale simulations, with several degrees of simplification.

Methods: The proposed model is based on the Rogers-McCulloch formulation of the FitzHugh-Nagumo equations. With respect to the Rogers-McCulloch formulation we added a transient outward current and a novel parameter to accurately fit the action potential morphology. We also modified the definition of the timescale of the recovery variable to fit the experimental restitution properties. The model was fitted to currently available human experimental data. Furthermore, our model includes a simplification parameter r_γ whose effect is to scale down the excitation current during the upstroke. To maintain the same conduction velocity, we also multiply the diffusivity by r_γ . Our approach allows increasing time and space integration steps by a factor equal to r_γ .

Results: Reduction in computational time is similar to the theoretical value: r_γ^3 in 2D and r_γ^2 in 1D. Our three-variable model can reproduce the main tissue-level characteristics of epicardial cells, such as action potential amplitudes and shapes, upstroke velocities, and action potential duration and conduction velocity restitution curves. Except for a reduced upstroke velocity, the simplification proposed does not affect action potential characteristics and restitution properties. In a 2D sheet, integral characteristics of reentry dynamics, such as dominant period and simulated electrogram, are only slightly influenced by the simplification. However, the trajectory of the spiral tip changes for different values of r_γ .

Conclusion: Due to the efficient computation, we believe the proposed approach could be useful in large-scale 3D simulations of heart electrical activity. Moreover, the simplification of our model can be tuned to the specific application by simply modifying r_γ . Finally, our formulation could also be extended to other types of cardiac cells.



Action potential for different simplification factors.