Negative filemant tension in Luo-Rudy model of cardiac tissue

Sergio Alonso[1*], Alexander V. Panfilov[2]

[1] Fritz-Haber Institute of the Max-Planck Society, Berlin, Germany
[2] Theoretical Biology, Utrecht University, The Netherlands
[*] Electronic Address: alonso@fhi-berlin.mpg.de

Excitable media support self-organized scroll waves which can be unstable and give rise to three-dimensional wave chaos. Typically, scroll waves rotate around a linear phase singularity, the filament, equivalent to the rotation of spiral waves around a circular core in two dimensional excitable media.

Rotation of a scroll ring is non-stationary because its filament drifts in space. Two main drift regimes are: filament contraction (positive tension) and filament expansion (negative tension) [1].

Negative filament tension may result in instability that was studied for linear filaments and scroll rings in simplified models of excitable medium [2, 3]. This instability could play an important role in the cardiac tissue where it may lead to ventricular fibrillation [4].

The aim of this study is to find if the negative filament tension and instabilities are possible in an ionic model of cardiac tissue. We employ the Luo-Rudy phase 1 model [5]:

$$\frac{\partial V}{\partial t} = -\frac{I_{ion}}{C_m} + D\Delta V \qquad (1)$$

Here V is the transmembrane potential, t is time, C_m is the membrane capacitance, D is the diffusion coefficient and I_{ion} is the sum of all transmembrane ionic currents. For I_{ion} we use $I_{ion} = I_{Na} + I_{si} + I_K + I_{K1} + I_{Kp} + I_b$. The corresponding equations for the currents and the gating variables as described in [5]. Parameter settings are as in the original model except for the I_{si}, I_{Na} conductances.

We perform numerical simulations in order to demostrate that Negative filament tension exists in the Luo-Rudy phase 1 model for parameter values corresponding to a low excitable cardiac tissue. Negative filament tension can induce electrical turbulence in a homogeneous slab of cardiac tissue.

---

[1] A. V. Panfilov and A. N. Rudenko, Physica D **28**, 215 (1987).

[2] V. N. Bikthasev, A. V. Holden and H. Zhang, Phil. Trans. R. Soc. Lond. A **347**, 611 (1994).

[3] S. Alonso, F. Sagués and A. S. Mikhailov, Science **299**, 1722 (2003).

[4] F. H. Fenton, E. M. Cherry, H. M. Hastings and S. J. Evans, Chaos **12**, 852 (2002).

[5] C. Luo and Y. Rudy, Circ. Res. **68**, 1501 (1991).