

Simple model for identifying critical regions in atrial fibrillation

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Abstract:

Atrial fibrillation (AF) is the most common abnormal heart rhythm and the single biggest cause of stroke. Ablation, destroying regions of the atria, is applied largely empirically and can be curative but with a disappointing clinical success rate. We design a simple model of activation wave front propagation on an anisotropic structure mimicking the branching network of heart muscle cells. This integration of phenomenological dynamics and pertinent structure shows how AF emerges spontaneously when the transverse cell-to-cell coupling decreases, as occurs with age, beyond a threshold value. We identify critical regions responsible for the initiation and maintenance of AF, the ablation of which terminates AF. The simplicity of the model allows us to calculate analytically the risk of arrhythmia and express the threshold value of transversal cell-to-cell coupling as a function of the model parameters. This threshold value decreases with increasing refractory period by reducing the number of critical regions which can initiate and sustain microreentrant circuits. These biologically testable predictions might inform ablation therapies and arrhythmic risk assessment.