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Abstract

The Atrial Resting Potential Distribution within a Fibrotic Zone and Its Effects on the Conduction on Non-Fibrotic Zones: A Simulation Study †

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Atrial fibrillation (AF) is a heart condition commonly diagnosed within the clinical praxis. During an AF episode, rapid and irregular heartbeats are present and they underly a complex electrical activity. It is known that the atrial structural alterations play a role in establishing the fibrillatory propagation patterns. However, the specific mechanisms are not fully understood. Fibrosis is a hallmark of AF and it represents structural abnormalities that disturbs the atrial electrical conduction. In this work, the behavior of the cardiomyocytes resting action potential in a fibrotic tissue, under distinct textures, is studied. A computational model of atrial electrophysiology is implemented. For the fibrosis model, spatial complex-order derivatives are used. Several values for the derivative order are tested in order to generate different degrees of structural complexity. The fibrosis model also includes cellular heterogeneity through the presence of fibroblasts coupled to cardiomyocytes. Diffuse, interstitial and compact fibrosis textures are implemented in a 2D domain and the amount of fibrosis is varied. The distribution of the resting potential is assessed using the Shannon entropy and the tissue is stimulated in order to evaluate the conduction velocity. The results indicate that, the distinct fibrosis structural conditions generate a wide range of resting potential distributions: from normal to heavy-tailed. The entropy values indicate the changes in the resting potential distribution when the structural complexity varies. Such analysis evinced that the amount of fibrosis generates specific entropy curves respect the derivative order. Moreover, the conduction velocity outside the fibrotic area is affected by the fibrotic configuration, which evinces the long-range effect of the fractional derivative operator and agrees with experimental observations. These results suggest that the proposed complex-order model can be useful for modeling fibrosis during atrial fibrillation and the entropy approach allows characterizing the wide range of fibrillatory scenarios under distinct fibrosis configurations.