Proliferation of Fibroblast Modulates the Action Potential Duration Dispersion: an Atrial Fibrosis Model Using Fractional Diffusion

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Background: Fibrosis, conjugated with an atrial fibrillation (AF) scenario can affect the genesis and perpetuation of the arrhythmia. Fibroblast proliferation, as a component of the fibrotic process, plays a role in structural remodeling, but also can alter the electrophysiology of the cardiomyocytes. The outcome of this interplay on the electrophysiological properties of the tissue is not fully understood.

Aim: To study the action potential duration dispersion (dAPD) in fibrotic atrial strands, where fibroblasts exerts both, structural and electrical influence on the propagation, using a fractional diffusion model.

Methods: We implement the Courtemanche model of human atrial cell, under chronic AF remodeling conditions. We design atrial strands as 1D domains, having a fibrotic portion localized in the middle. Fibrosis is modeled taking into account an electrical component, implemented by coupling a number of fibroblasts to a single cardiomyocyte, and a structural component, implemented through a q-order fractional derivative. The dAPD is measured. We assign a density of cardiomyocyte-fibroblasts components ranging from 0% to 100%. The number of fibroblast per cardiomyocyte varies from 0 to 60. We test distinct values for q ranging from 1.1 to 2.

Results: From our results we identified that q variations define two dAPD dispersion regimes. For $q \leq 1.4$, the fibrosis density and the number of fibroblast per cardiomyocyte do not alter the dAPD. For $q \geq 1.5$, the dAPD depends on the fibrosis spatial characteristics. Specifically, the dAPD increases with the density of fibrosis, as well with the number of fibroblasts per cardiomyocyte. The transition between these two regimes occurs in the interval $1.4 < q < 1.5$. We observed that

Conclusion: This study shows that the structural component of fibrosis, modeled using fractional diffusion, modulates the spatial dAPD in a domain including electrical coupling of cardiomyocytes and fibroblasts, under chronic AF conditions.