Influence of Fibrotic Tissue Arrangement on Intracardiac Electrograms During Persistent Atrial Fibrillation

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During persistent atrial fibrillation, cardiac tissue undergoes electrophysiological and structural remodeling. Fibrosis in the atrial tissue has an important impact on the myocyte action potential (AP) and its propagation. The objective of this work is to explore the effect of heterogeneities present in the fibrotic tissue on the intracardiac electrogram (EGM). Human atrial myocyte and fibroblast electrophysiology was simulated using mathematical models proposed by Koivumäki et al. representing electrical remodeling under peAF as well as a remodeling due to the paracrine effect of the transforming growth factor β1 (TGF-β1). 2D tissue simulations were performed using the monodomain approach and EGM forward calculations with the infinite conductor approximation. Furthermore, we varied the density of fibrosis (10%, 20%, 40%) present in a circular region of 2cm diameter. We also varied the ratio of myocytes coupled to myofibroblasts vs. collagen in fibrotic elements (0%-100%, 25%-75%, 50%-50%, 75%-25%, 100%-0%). Results show that increasing the fibrosis density changes the reentry dynamics from a functional to an anatomical reentry due to a block of conduction in regions with high fibrosis density (40%). Higher densities of fibrosis (40%) had a more homogenous distribution of Shannon entropy values inside the fibrotic region. EGM morphology was affected by the ratio of myofibroblasts vs. collagen. For low myofibroblast ratios (<50%), the mean duration of the active segments inside the fibrotic region were shorter (43.8 ms, 61.48 ms and 45.83 ms for 10%, 20% and 40% of fibrosis correspondently) compared to higher myofibroblast ratios (45.66 ms, 62.24 ms, 48.09 ms for 10%, 20% and 40% of fibrosis correspondently). Our results show that fibrosis arrangement can alter the dynamics of reentry and EGM morphology.