Substrate-Specific Simulations of Atrial Fibrillation Reproducing Electrophysiological Clinical Markers

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Digital Twins able to reproduce atrial fibrillation (AF) phenotypes could help to determine the optimal therapy. This study uses a detailed computational model of atrial electrophysiology to identify the parameters that allow adapting AF simulations to reproduce clinically measured markers such as conduction velocity (CV) and cycle length (CL).

We have built a 3D model of the human atria, coupled with the Koivoumäki cell model, that considers anisotropy and conductance differences in the ion conduction channels of I_{to}, I_{CaL}, I_{Kr}, I_{K1} and I_{Ks} across atrial regions. Simulations of functional reentries (fig. 1a) in left atrium (LA) including AF progression, variations in electrical remodeling and diffusion, were performed, where CV and CL markers were measured at 7 points distributed over the atria.

The atrial model reproduced differences on the transmembrane potential curves according to experimental studies. On chronic AF, CV increased with diffusion percentage in all atrial regions (fig. 1b). It increased from 231.68 mm/s to 584.49 mm/s in the LA and covered the physiological AF range from 100 to 900 mm/s for diffusion variations from 25% to 100%. CL in regions close to the reentrant activity decreased as remodeling increased (LA from 229.71 ms to 172.40 ms for 125% remodeling, fig c). In general, variations in remodeling degree allowed to reproduce the CL range from 160 to 350 ms.

Electrical parameters such as degree of electrical remodeling and diffusion can be used to fit detailed atrial simulations to reproduce the CV and CL markers observed in clinical practice. This will make it possible to obtain Digital Twins fitted to the patient-specific AF phenotype, able to reproduce specific AF mechanisms and to predict the outcome of potential therapies.

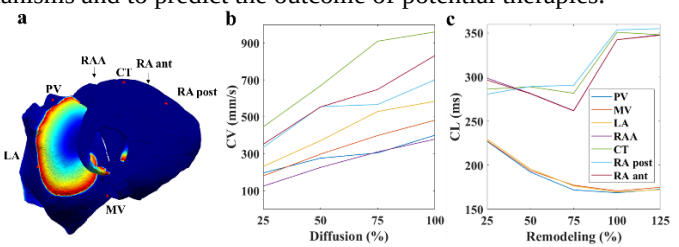

Figure 1. a) Points to measure CL and CV. b) CV for different diffusions and 125% remodeling. c) CL for different remodeling and 25% conductance.