Patient-Tailored In Silico 3D Simulations and Models from Electroanatomical Maps of the Left Atrium

Gonzalo R Ríos-Muñoz[1,2*], Sara Rocher[3], Antonio Artés-Rodríguez[1,2], Ángel Arenal[2], Javier Saiz[3], Carlos Sánchez[4]

[1]Universidad Carlos III de Madrid, [2]IiSGM, Madrid, [3]Ci[2]B, Universitat Politècnica de València, [4]CUD, BSICoS, CIBER-BBN, Zaragoza, Spain

Aims: The main goal of this study is to perform in silico arrhythmia simulations using patient-specific 3D left atrium (LA) geometries. We propose a method to generate realistic 3D LA models from electroanatomical (EA) maps performed during atrial fibrillation (AF) ablation procedures, as an alternative to CT and MRI 3D modelling.

Methods: 28 EA maps from persistent AF patients performed with a multi-electrode catheter were used. Maps were exported and post-processed to obtain 3D geometries, with a resolution of 300 μm (i.e. the size of each hexaedral element). The LA was manually segmented into 5 regions: atrial wall, atrial appendage, left PVs, right PVs, and mitral valve ring. All regions included wall thickness (600 μm), fibre orientation, anisotropy, and tissue heterogeneities. Cell electrophysiology was implemented using the Maleckar et al. model, and simulations were performed using finite-element methods.

Results: We obtained 28 LA models following the steps shown in Figure 1. The number of 3D elements for atrial thickness was around 900k (depending on each patient's LA size). We achieved to simulate sinus rhythm, re-entries and sustained AF scenarios with different stimulation protocols. Simulated electrograms (EGMs) were consistent with experimental measurements. In some patients exceptions were found in terms of EGM morphology and voltage range, probably due to fibrotic tissue presence, not included yet in the models.

Conclusions: EA maps become an alternative to MRI based methods to obtain patient-specific geometries. We present a simple way to generate patient-tailored models, with reproducible steps leading to reliable simulations of electrical propagation in the human heart.

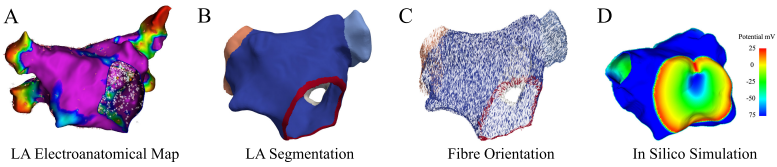

Figure 1. A-D Steps performed to obtain in silico simulations from EA maps.