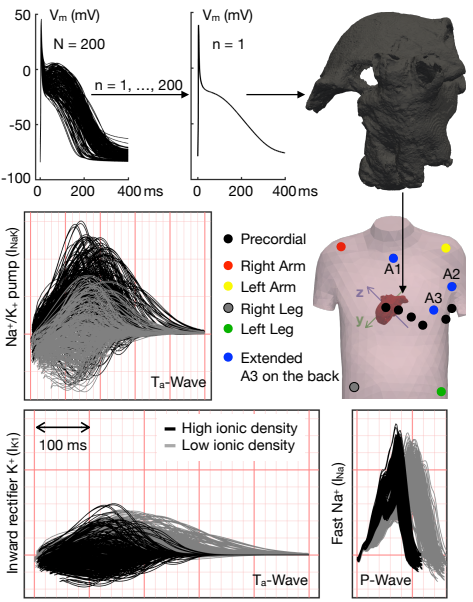
Electrogram analysis reveals ionic current dysregulation relevant for atrial fibrillation

Albert Dasí[1], Claudia Nagel[2], Axel Loewe[2], Alfonso Bueno-Orovio[1], Blanca Rodriguez[1]

[1] Department of Computer Science, University of Oxford, Oxford, UK
[2] Institute of Biomedical Engineering, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Antiarrhythmic drug choice for atrial fibrillation (AF) neglects the individual ionic profile of the patient, which has proven influential in drug safety and efficacy. We hypothesize that the electrocardiogram (ECG) might contain crucial information to aid in pharmacological treatment personalization. Thus, this study aims to use modeling and simulation to assess the extent of atrial ionic information embedded in the ECG.

A dataset of 1,000 simulated 15-lead ECGs was computed in sinus rhythm using a population of human-based whole-atria models with 200 individual ionic profiles (Figure) and 5 different torso-atria orientations (i.e., rotations around the y- and z- axis; Figure). A neural network was built to predict key atrial ionic conductances based on P- and T_a-wave biomarkers.



The fast Na^+ (I_{Na}) and inward rectifier K^+ (I_{K1}) currents regulated P- and T_a-wave duration, respectively (Figure). In turn, the Na^+/K^+ pump (I_{NaK}) and rapid rectifier K^+ (I_{Kr}) currents determined the T_a-wave amplitude and complexity (i.e., number of local peaks). Accordingly, the ionic density of these currents was predicted with >80% precision and recall. Further ionic currents relevant for AF, such as the ultra-rapid rectifier K^+ (I_{Kur}) and L-type Ca^{2+} (I_{CaL}) currents, were also identified with ~80% precision.

Thus, a non-invasive characterization of the ionic profile of the atria resulted from analyzing the P- (i.e., I_{Na}), T_a- (i.e., I_{K1}, I_{NaK}) or both waves (i.e., I_{Kur}, I_{Kr}, I_{CaL}). This could improve patient stratification, cardiac safety and the efficacy of AF pharmacological treatment.