Predicting the Origin of Outflow Tract Ventricular Arrhythmias using Machine Learning Techniques trained with Patient-Specific Electrophysiological Simulations

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Motivation: Being able to identify the site of origin (SOO) of Outflow Tract Ventricular Arrhythmias (OTVAs) is important to plan radiofrequency ablation procedures. Depending on the SOO, a different approach is needed. Although clinicians have developed several algorithms to predict left versus right origins based on electrocardiograms (ECG), their accuracy is limited.

Aims: The aim of this work is to determine the SOO by using machine learning approaches trained with patient-specific electrophysiological simulations of subjects that suffer OTVA. We want to assess the best ECG-based index to train the models and predict the SOO using as input data the simulated ECG and the body surface potential maps (BSPM). Results of simulations are then compared with patient ECG data.

Methods: Biophysical simulations of electrical ventricular depolarization and their corresponding ECGs and BSPM were obtained for 11 OTVA patients, each one with a different SOO according to clinical diagnosis: right ventricle outflow tract (RVOT); Right Coronary Cusp (RCC) and Left Coronary Cusp (LCC) in the left ventricle outflow tract (LVOT). Ten different SOO were simulated for each patient-specific geometry using a fiber orientation model specific of the ventricle outflow tracts. A support-vector machine (SVM) was trained using the BSPM simulated data and the label indicating the SOO of each simulation.

Results: We obtained 10 OTVA simulations (see Fig. 1a) for the 11 patient-specific models built and calculated the corresponding BSPM by solving the forward problem. We first validated the results comparing simulated versus real ECGs, obtaining a good agreement between the polarity and the evolution of the signals. Subsequently, we used the QRS complex integral in the BSPM to train our SVM and classify the different SOO. According to our results, V3 lead provides useful information for SOO localization (see Fig. 1b). Obtained classification rates show that simulated BSPMs can help to determine RVOT versus LVOT origin.

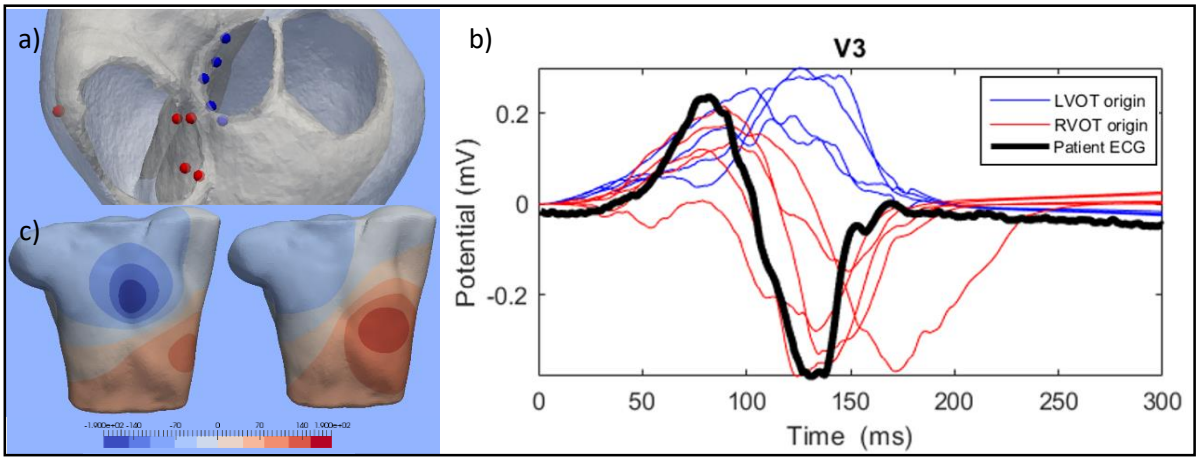

Figure 1: a) SOO of the OTVA simulations. (Right ventricle SOO points are shown in red color and left ventricle SOO in blue color). b) Simulated ECGs (V3 lead) in a RVOTA patient geometry. ECGs with a LVOT origin are pictured in blue whereas RVOT ECGs are in red. The black line corresponds to the real ECG of the RVOT patient. c) Differences between two BSPM. In left, the one corresponding to a RVOT origin and in right to a LVOT origin.