ELECTROMECHANICAL WAVE IMAGING FOR NONINVASIVE AND DIRECT MAPPING OF ARRHYTHMIAS IN 3D

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Abstract

Arrhythmias refer to the disruption of the natural heart rhythm. This irregular heart rhythm causes the heart to suddenly stop pumping blood. Arrhythmias increase the risk of heart attack, cardiac arrest and stroke. Reliable mapping of the arrhythmic chamber stands to significantly improve these currently low treatment success rates by localizing arrhythmic foci before the procedure starts and following progression throughout. To this end, our group has pioneered Electromechanical Wave Imaging (EWI) that characterizes the electromechanical function throughout all four cardiac chambers. The heart is an electrically driven mechanical pump that adapts its mechanical and electrical properties to compensate for loss of normal mechanical and electrical function as a result of disease. During contraction, the electrical activation, or depolarization, wave propagates throughout all four chambers causing mechanical deformation in the form of the electromechanical wave. This deformation is extremely rapid and completes within 15-20 ms following depolarization. Therefore, fast acquisition and precise estimation is extremely important in order to properly map and identify the transient and minute mechanical events that occur during depolarization. Activation maps are generated based on the zero crossing of strain variation in the transition from end-diastole to systole. Our group has demonstrated that EWI yields 1) high precision electromechanical activation maps that include transmural propagation and 2) imaging of transient cardiac events (electromechanical strains within ~0.2-1 ms). Our studies have also shown the EWI capable of capability atrial fibrillation and atrial flutter, transmural atrial pacing, RF ablation lesions while more recently it has been shown more robust that 12-lead EKG in characterizing focal arrhythmias such as the Wolf-Parkinson-White (WPW) and pre-ventricular Contraction (PVC) as well as macro-reentrant arrhythmias in patients. Two machine learning aspects will be described. The first entails the use of Machine Learning (ML) techniques to automate the zero crossing estimates in the generation of the EWI activation maps by using Logistic Regression and Random Forest methods. The second ML application will include EWI mapping at lower imaging framerates used so far (<500 Hz) in order to determine what percentage of the activation maps can be reconstructed based on unsupervised training data at higher framerates. The quality of performance of EWI can be further enhanced by ML methodologies.

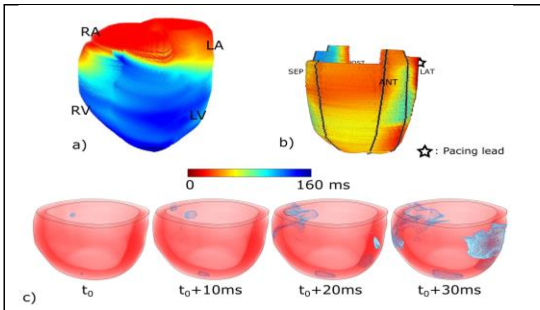

Figure 1. a) 3-D isochrone map of a full NSR heart (LA/RA: left/right atrium, LV/RV: left/right ventricle), b) 3-D isochrone of a canine left ventricle paced from the lateral side (star denotes the lead location), c) EWI frames of the activation ciné loop of the left ventricle showing the EWI wavefront in blue for speed calculation.