Automated isochrone generation approaches for localization of accessory pathways in Wolff-Parkinson-White patients with Electromechanical Wave Imaging using Machine Learning

Lea Melki[1], Elisa E. Konofagou[1, 2]

[1] Department of Biomedical Engineering, Columbia University, New York, NY, USA.
[2] Department of Radiology, Columbia University, New York, NY, USA.

Background, Motivation and Objective

Accessory pathways (AP) in Wolff-Parkinson-White (WPW) syndrome are commonly treated with catheter ablation. Localization of the AP prior to ablation is crucial for pre-procedure planning. Electromechanical Wave Imaging (EWI), high frame-rate ultrasound modality, can non-invasively map the activation sequence of the heart. EWI isochrone generation usually relies on a time-consuming manual selection of zero-crossing (ZC) locations on incremental axial strain curves. Reducing inter-observer variability would improve the robustness of EWI. In this study, we evaluated different automated ZC detection algorithms and compared their performance against the manual selection approach for accurate localization of APs in patients.

Statement of Contribution/Methods

A 2 kHz diverging sequence was used to transthoracically image 24 patients (aged 7-67, 54% male) immediately prior to ablation with a 2.5MHz phased array, and 8 were re-scanned after successful ablation. EWI processing was performed on the four apical views as previously published (Melki et al. 2019). Manually generated isochrones were validated against 3D intracardiac mapping and considered as ground truth for the automated approaches. Strain curve features were automatically collected: positive to negative ZC locations, slope at each ZC, peak positive and negative values surrounding each ZC along with their location. We performed 3 automated approaches: (1) a heuristic-based algorithm that always picks the first ZC, and 2 machine learning models (2) logistic regression and (3) a random forest classifier. The models were trained on 16 patients and tested on 8 (17 364 resp. 8055 samples).

Results/Discussion

Manually generated isochrones were shown capable of accurately localizing the APs in all patients, as well as successfully assessing the difference in electromechanical activation between before and after successful ablation on 8 patients. The ZC detection automated approaches were evaluated with respective accuracy and sensitivity metrics (%) as follows: (1) 63.9 & 67.4; (2) 66.3 & 69.5; (3) 88.4 & 89.5. The random forest (Fig. D) voting algorithm exhibited the highest performance with isochrones most similar to the ground truth (Fig. A). These findings indicate that using a machine learning approach can reduce user-variability while preserving accurate electromechanical activation patterns.

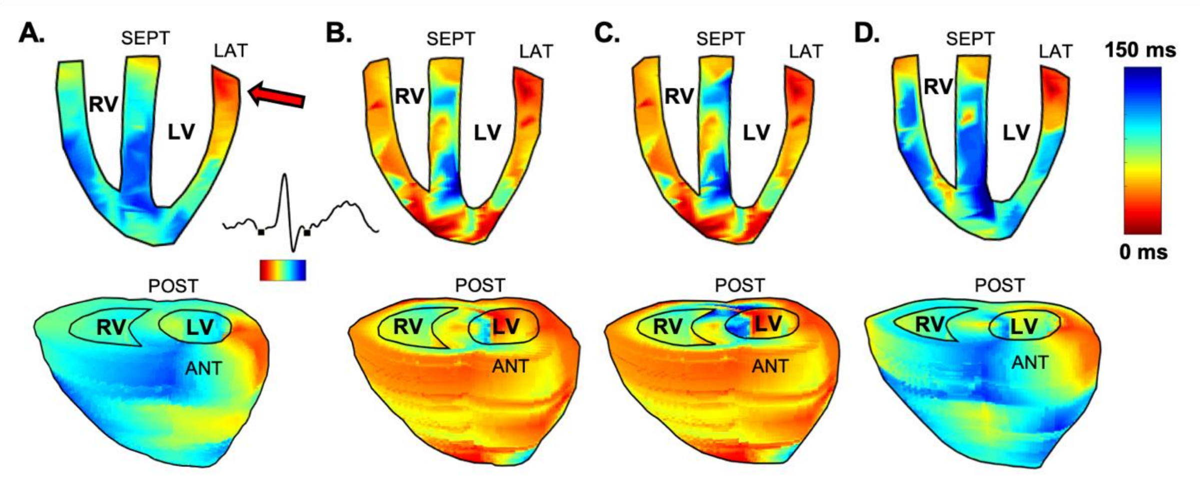

Fig. EWI four-chamber view (top) and 3D-rendered (bottom) ventricular isochrones of a left lateral AP in a 37-year-old female prior to ablation. **A.** Manually selected ZCs (ground truth validated with EnSite 3D intracardiac map); **B.** First detected ZCs; **C.** Logistic regression ZCs; **D.** Random forest ZCs.