Local Activation Time Estimation in Atrial Regular-Rhythms with ECGI

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Local activation times (LAT) are widely used during invasive mapping of the atria for regular arrhythmia characterization or conduction velocity estimation. However, there has yet to be a consensus on how to compute LATs in atrial signals estimated with electrocardiographic imaging (ECGI). This study aims to compare three different LAT estimation methods using in-silico data.

Cellular-Automata simulations over 3D volumetric atrial models were used. The simulations included 30 ectopic beats and 1 sinus rhythm simulation with different cycle lengths. Forward and inverse electrocardiographic problems were solved with four different signal-to-noise ratio levels. LATs were estimated on the inverse computed electrograms (iEGM) as the maximum negative deflection (-dv/dt), the maximum negative deflection after applying a Gaussian convolution on the temporal derivative of iEGMs (Gaussian method), and using Hilbert's phase-transformed signals to localize the activation time (Phase-based method). These methods were also tested in combination with a spatial anisotropic filter. LAT maps obtained before and after spatial filtering were compared to activation maps computed on the simulated EGMs using Pearson correlation.

Max-deflection showed the lowest correlations (0,36±0,20). Spatial filtering increased the correlation of LAT maps in all the methods. Phase-based and Gaussian methods perform similarly under low-noise conditions (for 20 dBs: 0,90±0,08 vs. 0,90±0,09 in filtered maps). However, Phase-based provided significantly higher correlations in noisier scenarios (for 0 dBs: 0,81±0,12 vs. 0,68±0,11 in raw maps and 0,83±0,13 vs. 0,77±0,12 in filtered maps). Therefore, using phase signals combined with anisotropic spatial filtering has been proven as a robust methodology for noninvasive LAT estimation in the atria.