

Fast And Accurate Reconstruction Of Transmural Activation Maps From Standard 12-lead ECG Using An Eikonal Model

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Abstract

Background Modern ECG imaging (ECGi) tools enable accurate, non-invasive evaluation of epicardial potential and activation from high-density body surface potential maps and patient-specific anatomy. Current ECGi tools, however, 1) are limited to the epicardium, with no septal and transmural information, 2) do not use prior knowledge on conduction velocity, and 3) require large lead sets.

Objective Implementing a model-based ECGi procedure capable of delivering a full 3D activation map using only on the standard 12-lead ECG and MRI of torso and heart.

Methods We created a model based on the eikonal equation and lead field theory, to efficiently simulate ventricular activation maps and the corresponding ECGs. Anatomy was segmented from MRI. Using an optimization procedure, we fitted the parameters of the model (local conduction velocity, early activation sites) to reconstruct the activation map. We validated the method against high-density electro-anatomical mapping from 8 candidates to cardiac resynchronization therapy.

Results A good correlation between recorded and simulated 12-lead ECGs was observed in all patients (0.77 ± 0.13), with an excellent match in leads V1–V3 (0.95 ± 0.05). The reconstructed activation closely matched endocardial activation maps: correlation was 0.85 ± 0.08 in the left ventricle (8 patients), 0.86 ± 0.10 in the coronary sinus (6 patients), and 0.56 ± 0.23 in the right ventricle (5 patients). The procedure took 5 ± 2.4 minutes on a desktop computer per patient.

