ECG Imaging of Biventricular Paced Ventricular Sequences

Danila Potyagaylo[1], Stepan Zubarev[2], Mikhail Chmelevsky[2]

[1] EPIQure GmbH, Karlsruhe, Germany [2] Almazov National Medical Research Center, Saint-Petersburg, Russia

Introduction: Cardiac resynchronization is the therapy to restore ventricular contractile function with a patient-specific ventricular pacing protocol. To become a complementary CRT tool for device optimization, ECG imaging should, thus, reliably reconstruct ventricular excitation sequences resulting from biventricular stimulations with different delays.

Methods: To address this challenge, we propose a regression model to identify sites of earliest ventricular excitation and their timings. First, we subdivide the cardiac volume into sub-voxels with 3 mm edge size, For training, 5000 times tuples are randomly selected that contain indices of voxels with the simulated earliest activations and temporal delays between them. To generate the respective training ECG signals, we use a simplified propagation model based on the geodesical epi- and endocardial distances and convert them to body surface potential maps (BSPM) with boundary element method. To test this model, we considered five patients who underwent a biventricular pacing protocol with time delays between the left and right ventricular stimuli ranging from 0 to 50 ms and compered the results to the classical Tikhonov regularization.

Results: The comparison revealed Tikhonov regularization tending to over smooth the solution and resulting in one large activation area for synchronous and 10 ms delay pacings. In contrast, the proposed regression model was able to detect two distinguished activation areas within 10 ms delay and 20 mm spatial errors for all considered cases.

Conclusions: The proposed combination of activation modeling, BSPM simulation and the inverse regression could estimate spatial location and temporal delay resolution for the biventricular pacings with acceptable clinical accuracy.