The Effect of Segmentation Variability in Forward ECG Simulation

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Background: Through Electrocardiographic Imaging (ECGI), non-invasive insight in cardiac activation is obtained. Segmentation of patient-specific anatomical models is one of the first steps in ECGI. However, the effect of segmentation variability on ECGI remains unexplored. In this study, we assess the effect of heart segmentation variability on body surface potentials (BSP) computed from an equivalent dipole layer formulation.

Methods: Fifteen cardiac segmentations of a single patient CT-scan were created by different observers, from which we generated a statistical shape model using ShapeWorks. The shape model was sampled into 262 cardiac geometries and, with the mean shape, discretized as triangulated surface meshes. Ventricular activation sequences for each shape were computed using the fastest route algorithm for five ventricular stimulation protocols (four paced beats and sinus beat). The equivalent dipole layer was used as a cardiac source and BSP were computed. The simulations from each of the sampled shapes were compared to the solution from the mean cardiac shape.

Results: Largest variation in cardiac shape was observed at the base of the heart, the lowest at the apex. An overall good correlation (0.98±0.02) was observed between activation sequences per stimulation protocol. The lowest variability in BSP was found for apical pacing (0.98±0.03) whereas the highest variability was found for right ventricular (RV) free wall pacing (0.90±0.23). BSP with low RS amplitude demonstrated a larger variation in CC compared to high RS-amplitude BSPs. Furthermore, per stimulation protocol, different leads were affected most (Figure). The highest variation in QRS duration (124.14±5.35 ms) was observed for the left ventricle free wall pacing.

Conclusion: The results indicate that the variation in cardiac shape directly affects computed BSP and consequently affects ECGI estimations. The analysis will be extended towards repolarization.

Figure: Average CC computed for all torso electrodes. The color of the electrode corresponds to the average CC computed per electrode for all shape models and the size of the dot increases with increasing standard deviation.