Optimizing cardiac source model accuracy by incorporating endocardial electro-anatomical structures

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Background: Solving the inverse problem in electrocardiography (*i*ECG) is used to non-invasively estimate the cardiac activation sequence. The most complex cardiac activation sequence is sinus rhythm, when the His-Purkinje system is involved. At the endocardial surface this is observed as multiple foci and structures like papillary muscles and the moderator band are involved. Therefore, incorporation of these electro-anatomical structures may improve robustness of modeling cardiac activation during sinus rhythm using an equivalent double layer based method. In this pilot study the influence of the incorporation of these structures on estimated initial activation sequence was tested.

Methods: Subject specific models were constructed using either cardiac CT or cardiac MRI. Per subject two anatomical models were created: 1) without electro-anatomical structures (fundamental model) and 2) with electro-anatomical structures (extensive model). Three initial foci were determined. For the initial estimation, recorded body surface potential maps (BSPM) were compared to simulated BSPM using correlation and relative difference. Initial foci locations were compared to physiological knowledge from endocardial mapping and in vitro studies.

Results: Cardiac activation patterns were estimated for the fundamental and extensive anatomical model (Figure 1). Correlation and relative difference values increased respectively decreased by increasing the amount of initial foci. For the fundamental model, 45% of all foci were found at the lower 1/3 of the left ventricular septum, 25% nearby papillary muscles at the left ventricular free wall and 33% nearby the moderator band insertion at the right ventricular free wall. For extensive models, percentages were 75%, 67% and 67% respectively.

Conclusion: Cardiac activation sequence in models with and without electro-anatomical structures behave similar to physiologically expected cardiac activation sequence. Incorporation of electro-anatomical structures are expected to improve the robustness of modeling cardiac activation sequences and might be a solid basis for the initial estimate for His-Purkinje activation.

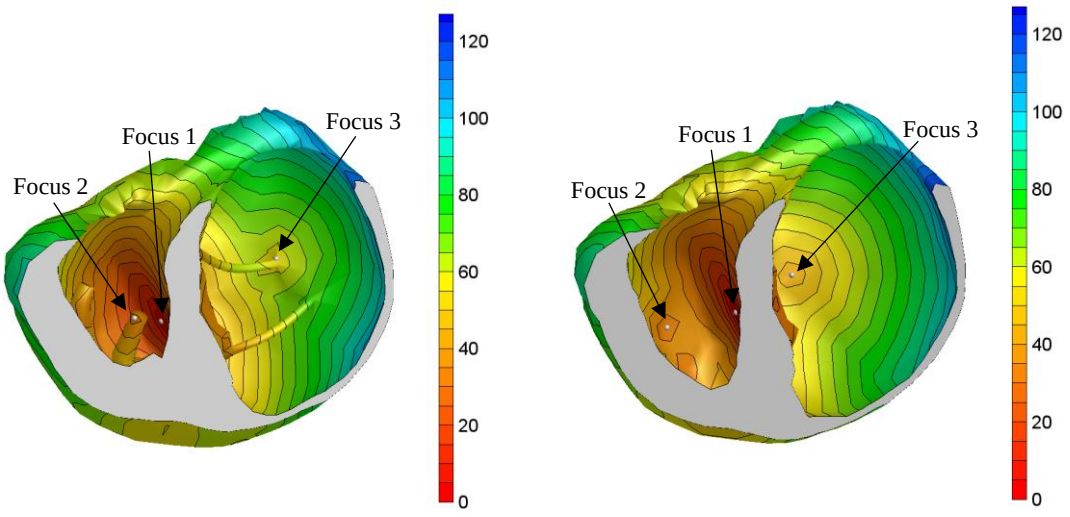

Figure 1 – Cardiac activation patterns in the extensive (left) and fundamental (right) model. Cardiac activation was estimated during the initial estimation and initial foci were represented as white dots (indicated with the black arrow) on the cardiac surface. The order of estimation was depicted with Focus 1, Focus 2 and Focus 3 in order of estimation. Activation timing was plotted using isochrones 5 milliseconds apart.