Predicting Activation Patterns in Cardiac Resynchronization Therapy Patients

A W C Lee, U C Nguyen, J Gould, B Sidhu, B Sieniewicz, C Mendonca Costa, F Prinzen, G Plank, C A Rinaldi, K Vernooy, S A Niederer

Background: Cardiac resynchronization therapy (CRT) is an effective treatment for heart failure patients. Suboptimal pacing timings and locations have been identified as causes for nonresponse to CRT. Cardiac computer models can be used to simulate the electrical activation and thus optimize CRT.

Aims: Identify which electrical properties of the human heart are important for predicting activation patterns in CRT patients.

Methods: Patient-specific models were used to predict the electrical activation of the heart, with the conduction velocity fitted to the QRS duration for 14 patients. Delayed enhancement cardiac MRI was used to personalize the geometry and delineation of scar. Intra-procedural coronary venous electro-anatomical mapping was performed during right ventricular pacing and the clinical measurements were used to identify the relative importance of scar, anterior or posterior functional block, slow septal conduction and fast endocardial conduction. Clinical measurements of the local activation times (LAT) were compared against the simulations to calculate the temporal errors. The distance errors were calculated as the product of the LAT error and the conduction velocity

Results: One-way ANOVA was used to compare the temporal and distance errors for the models incorporating the scar, functional block, slow septal conduction, and fast endocardial conduction. Differences were found in the distance errors for the models ($F(5,78)=8.87$, p-value <0.0001), though not for the temporal errors (p-value>0.1). Tukey post-hoc tests indicated that the fast endocardial conduction model had a significantly reduced mean distance error (6.8mm) in comparison to the other models (15.8-17.8mm).

Conclusion: In CRT patients the electrical activation pattern is dependent on the presence of fast conducting endocardial tissue, which may be important in predicting optimal pacing locations and timings.