Rapid estimation of 3D ventricular activation from electroanatomic mapping

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TITLE

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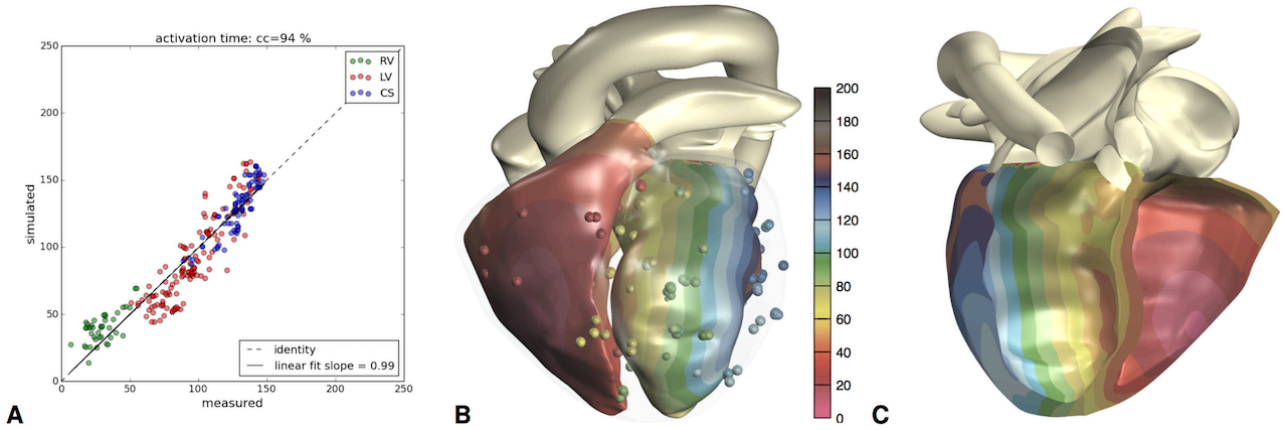
ABSTRACT

Purpose Heart failure patients are often affected by a ventricular conduction disorder. Accurate characterization of the tridimensional (3D) activation sequence of the ventricles is fundamental for an effective personalized therapy. Electroanatomical mapping provides the activation times at the endocardium, with limited coverage due to anatomical constraints. Our aim is to develop a robust tool to generate a complete 3D, biventricular activation map from a limited number of endocardial measurements.

Method In 6 candidates to cardiac resynchronization therapy a high density endocardial activation map of the right and left ventricle was obtained. High resolution propagating activation was simulated in patient-tailored anatomical heart models using the anisotropic eikonal equation and realistic fiber orientation. Subsequently, the mean square error between the measured and simulated activation times was minimized by varying early activation site(s) and local anisotropic conduction velocities.

Results. A close correlation was achieved between the simulated and measured activation time for a single patient (Panel A) while detailed 3D activation maps were achieved (panel B and C). In all cases, the optimal parameters were identified within few minutes and the full activation sequence was computed in less than 2 seconds. A 0.9 to 0.95 Pearson correlation between measured and simulated activation times was obtained in all cases. The mathematical formulation is flexible in terms of the number of activation sites and a possible delay between them, in order to mimic the presence of a partially working Purkinje network.



Conclusion Our methodology is able to generate in a clinically affordable computational time (few minutes) reliable, patient-specific, fully volumetric activation map of both ventricles using a local workstation or a laptop.