Validation of Intramural Wavefront Reconstruction And Computation of 3D Conduction Velocity

Wilson W. Good[1], Karli Gillette[2], Jake A. Bergquist[1], Brian Zenger[1], Jess Tate[1], Gernot Plank[2], Rob S. Macleod

[1] Scientific Computing and Imaging Institute, Biomedical Engineering, University of Utah, Salt Lake City, UT, USA

[2] Institute of Biophysics, Medical University of Graz, Graz, Austria

Abstract

Introduction: *Changes in conduction velocity are indicative of a wide variety of cardiac abnormalities yet measuring conduction velocity is challenging, especially within the myocardial volume. In this study we investigated a novel technique to reconstruct activation fronts and estimate three-dimensional (3D) conduction velocity (CV) from experimental intramural recordings.*

Methods: *Our method is based on irregularly sampled electrograms from within the myocardium, which we capture in experiments using intramural needle electrodes. From the electrograms we reconstruct the activation profile, which we use to compute the gradient of the activation times and a series of streamlines. Onto these streamlines we then map the activation times to estimate 3D conduction velocity along the streamline. To assess the accuracy of our reconstruction techniques, we utilized the CARPentry simulation platform, which calculated the activation times throughout the region sampled by the intramural needles. We then compared our simulated activation times to those we reconstructed. We also used CARPentry's simulations to validate our estimation of 3D CV.*

Results: *The reconstructed activation times agreed closely with simulated values, with an average RMSE of* $0.65ms$ *and* 89% *percent of the volume with errors* $< 1ms$*. We found close agreement between the CVs calculated using reconstructed versus simulated activation times. Across the reconstructed stimulations sites we saw an average CV of* $459cm/s$ *with a standard deviation of* $131cm/s$ *versus* $435cm/s$ *with a standard deviation of* $132cm/s$ *with simulated data.*

Discussion: *This study used simulated datasets to validate our methods for reconstructing 3D activation fronts and estimating conduction velocities. Our results indicate that our method allows accurate reconstructions from sparse measurements, thus allowing us to examine changes in activation induced by experimental interventions such as acute ischemia, ectopic pacing, or drugs.*

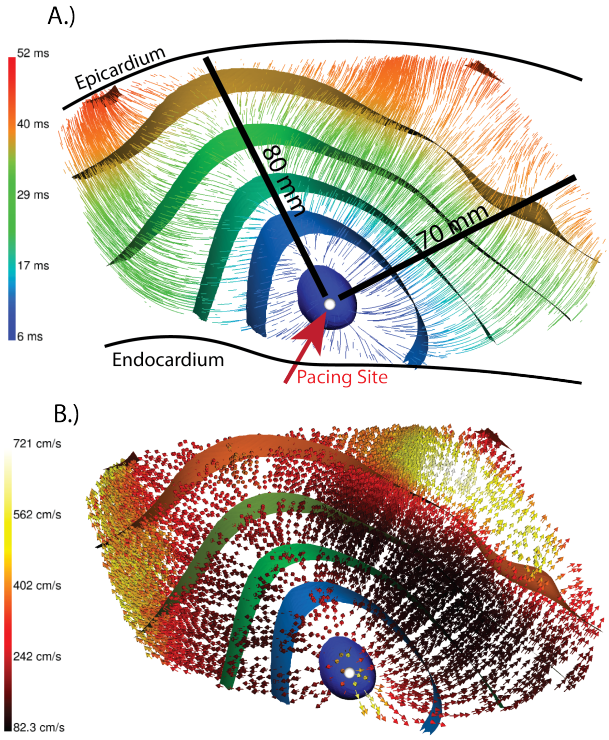

Figure 1. A two-dimensional cut plane of a simulation of a point stimulation at an endocardial region within the convex hull created by our intramural needles. The location of stimulus is indicated by the white sphere. A.) A series of isochrons marked at $7, 13, 20, 30, 38, 45ms$ with streamlines navigating the field with activation times mapped onto the streamlines. The pacing site and estimations of the epicardial and endocardial boundaries are indicated. B.) The same isochrons are indicated in A but with 3D conduction velocity vectors mapped in the field. The vectors are scaled and colored by conduction velocity magnitude.