Local Conduction Velocity Estimation during Wavefront Collisions and Reentrant Scenarios

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Background. Conduction velocity (CV) is an important electrophysiological biomarker for identifying slow-conducting cardiac regions related with a pro-arrhythmic behavior. Measurement of CV is challenging during irregular activation patterns, such as those present during tachycardia and fibrillation because of the complexity of the underlying mechanics.

Methods. We propose an approach for CV estimation designed for taking into account reentries and wavefront collisions. The algorithm is based on a set of constraints imposed to the inhomogeneity of velocity vector fields. Performance of the proposed algorithm was evaluated against the reference inverse spatial gradient by using an eikonal-diffusion computational model for reentries over a left atria anatomy with different mesh resolutions (regular triangles of 0.2 - 44.3 mm^2 mean area) and complexity of the propagation patterns (1 - 8 singularities).

Results. CV distributions were estimated on generated LAT distributions (Panel a), using an imposed CV map in the eikonal-difussion approach (Panel b). By applying the inverse spatial gradient directly results in an artificial propagation delay or CV overestimation when wavefronts are colliding (Panel c). The proposed methodology reduces errors of both effects (Panel d). The performance of our proposed method does improve that the reference inverse spatial gradient, with an increased percentage of nodes in which CV is estimated correctly (60.8 ± 7.1 % vs 78.1 ± 10.7 %).

Conclusion. A novel algorithm to quantify CVs that has been designed to account for scenarios present during arrhythmias, such as reentrant activity or wavefront collision. By imposing restrictions in the inhomogeneity of the detected activation directions, it allows for a lower error in the estimation of CVs in the setting of complex activation patterns.