Feasibility of ECGI Endocardial solutions in localizing the VT reentrant circuit

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Background: Electrocardiographic imaging (ECGI) has demonstrated significant potential in reconstructing the overall activation pattern on the epicardial surface and therefore, have been utilized for detecting diverse arrhythmias such as Ventricular Tachycardia (VT). However due to the loss of finer details of local activation, the feasibility of ECGI endocardial solutions for VT mapping has not been well understood.

Objective: Our goal is to evaluate the reliability and feasibility of endocardial ECGI solutions in categorizing the location of the reentrant circuit as either epicardial, endocardial, or mid-wall 3D circuit.

Method: Laplacian Eigenmaps (LE) is a technique for dimensionality reduction and visualization. It constructs a graph based on pairwise similarities between data points, computes the Laplacian matrix, and applies eigenvalue decomposition to obtain a low-dimensional embedding. Computing the LE of ECGI solutions on the left ventricle, we detected a pattern for capturing the endocardial breakthrough time (t_Endo). Given t_Endo using LE and epicardial breakthrough (t_Epi) by eyeballing, we considered the order of activation (t_Epi - t_Endo) and defined two categories explaining whether the VT circuit is closer or on the epicardium or endocardium surface.

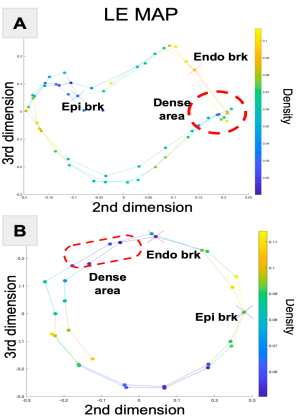

Figure 1: LE map 2nd vs 3rd dimension

Results: The proposed method is validated on 23 simulation data generated on eight chronically infarcted porcine hearts. The LE method identified the endocardial breakthrough on 21/23 cases **as the time of exiting the densest part of the LE map** as shown in Fig.1. The timing absolute error is 14.3 ± 13.2ms and 19/21 successful cases were correctly classified as either closer to epicardium or endocardium surfaces.

Conclusion: Although losing accuracy on activation maps, the ECGI solution has the potential to provide correct timing information about endocardial breakthroughs via the use of the LE method. This allows us to combine epicardial and endocardial breakthrough timing to determine the intramural nature of VT circuits.