Experimental Validation of a Novel Extracellular-Based Source Representation of Acute Myocardial Ischemia

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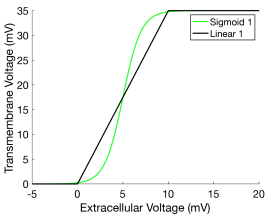
Introduction: Electrocardiographic imaging (ECGI) based detection of myocardial ischemia requires an accurate formulation of the source model, which includes a relationship between extracellular and transmembrane potentials (TMPs). However, this relationship is not well understood and often parameterized based on arbitrary potential thresholds and isotropic distance-based transitions between healthy and ischemic tissue. In this study, we used a combination of high-resolution intramural experimental recordings and forward modeling to examine the relationship between extracellular potentials and TMPs during myocardial ischemia.

Methods: We measured extracellular electrograms from intramural plunge needle arrays during seven controlled episodes of ischemia in an animal model. We used three source representations of TMPs: (1) parameterized and distance-based (defined previously), (2) extracellular based linear transform, and (3) extracellular based sigmoidal transform. The parameterized source was defined at the ischemic boundary based on thresholded extracellular potentials and consisted of an isotropic transition of TMPs from healthy to ischemic tissues. Both the linear and sigmoidal transforms used extracellular potentials to estimate TMPs, as shown in Figure 1. TMPs for each source formulation were then used to compute extracellular potentials by calculating the passive bidomain forward solution throughout the myocardium. Measured and computed potentials were then compared at electrode locations for accuracy using standard metrics of root mean squared error (RMSE), spatial correlation (SC), and temporal correlation (TC).

Results: Linear and sigmoidal approaches produced improved results compared to the parameterized method. The RMSE, SC, and TC of linear, sigmoidal, and parameterized methods were 0.85 mV, 1.21 mV, and 3.37 mV; 0.91, 0.88, and 0.47; 0.90, 0.77, and 0.33 respectively.



Conclusions: We found that extracellular-based calculations of TMPs produced superior forward computations compared to parameterized zones. These results suggest improvements to the detection of acute myocardial ischemia with ECGI by adjusting the source model formulation. Future studies will explore how different source formulations affect computed torso surface signals.