Effect of Interpolation and Resolution on Electrical LAT Map Interpretation

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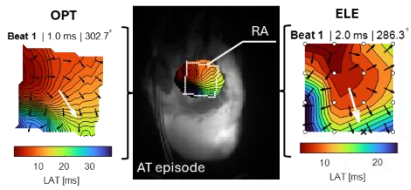
Introduction: Local activation time (LAT) maps derived from clinical electro-anatomical mapping systems are used to support mechanism identification and localization to guide catheter ablation. However, these maps are reconstructed from sparse electrode recordings and rely heavily on spatial interpolation to generate continuous activation patterns. While interpolation enables visualization, its impact on the physiological interpretation of cardiac propagation remains poorly understood. In this study, we evaluate how interpolation strategy and spatial resolution influence electrical LAT map interpretation using simultaneous high-resolution optical mapping and electrical recordings.

Methods: Optical–electrical recordings were acquired in Langendorff-perfused rabbit hearts during three sinus rhythm (SR), one atrial tachycardia (AT), and one ventricular tachycardia (VT) (4 beats each). Signals were processed using standard filtering. LAT was estimated by electrical recordings using -dV/dt and from optical signals using 50% criteria. Electrical LAT maps from a 4×4 multi-electrode array were reconstructed using Laplacian (LAP) and linear Delaunay (DEL) interpolation across 5×5, 11×11, and N×N grids (matching the optical resolution). Propagation was quantified using activation range, global direction, and spatial similarity (Dice coefficient).



Optical and electrical LAT maps during an atrial tachycardia (AT) episode

Results: Electrical maps exhibited larger activation ranges than optical across rhythms. Increasing grid density from 5 to 11 improved directional agreement in most SR cases (e.g., SR1 and SR3), while specific cases (e.g., SR2) showed large discrepancies (>50°), indicating condition-dependent behavior rather than systematic improvement with resolution. Spatial similarity increased with intermediate grids, reaching a maximum Dice of ~0.82 using DEL in SR (LA, 11×11). In AT, Dice values showed modest improvement with resolution and reduced differences between interpolation methods. In VT, agreement remained moderate (~0.60) for both methods.

Conclusion: Interpolation does not replace signal measurement. Increasing spatial resolution improves agreement only up to an intermediate level, with condition-dependent effects. DEL showed higher agreement in SR, while differences between methods diminished in arrhythmic conditions.