In-silico Framework for Estimation of Atrial Septal Ectopic Beats: A Combination of Mathematical Models, Electrocardiographic Imaging, and Support Vector Machines

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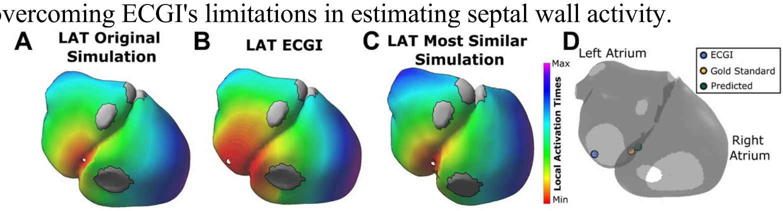
Introduction: Electrocardiographic Imaging (ECGI) allows the estimation of cardiac electrical propagation on the epicardium but does not accurately reflect septal ectopic activations. This study introduces a novel framework merging mathematical simulations, ECGI, and Support Vector Machine (SVM) models to enhance localization within septal regions.

Methods: We conducted 17,220 cellular automata simulations of atrial ectopic beats across the epicardial surface and within the atrial septum. Geometries for cardiac and torso models were generated from statistical shape models, and ECGI was computed for the simulations. Local activation time (LAT) maps were computed, and a novel framework with SVM models was developed to identify septal ectopic beats. We compared the earliest activation sites (EAS) of LAT maps detected by ECGI with those selected by our framework to identify the most similar simulation.

Results: SVM models achieved an accuracy of 100% in classifying septal and non-septal beats and 90% accuracy in identifying left and right septal ectopic beats. Furthermore, our approach reduced EAS location error from 2.37±1.01 cm (ECGI alone) to 0.46 ± 0.24 cm.

Conclusion: This study demonstrates the potential of integrating simulations, ECGI, and machine learning to advance cardiac arrhythmia diagnosis, overcoming ECGI's limitations in estimating septal wall activity.



Example of an improvement on the EAS detection of a simulation of a septal ectopic beat. Local activation time (LAT) maps of the original simulation, the ECGI, and the most similar simulation. White dots represent the EAS. D. Representation of the EAS estimated by ECGI, the predicted after applying the developed framework, and the gold standard.