Spatiotemporal Correlation Analysis of Cardiac Activation Patterns In Langendorff-Perfused Human Hearts: Insights For Arrhythmia Prediction

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Aims: T-wave alternans (TWA) is a crucial biomarker to predict arrhythmias and sudden cardiac death, and disruptions in action potential generation have been linked to its genesis. In this study, we propose to analyze the epicardial and endocardial dynamics of a Langendorff-perfused human heart ventricle under pacing-down restitution protocols to gain insights into the spatiotemporal dynamics of electrical activity and extract features that could be included in mathematical models to advance our predictive power on cardiac arrhythmias.

Methods: We used optical mapping voltage recordings on ex-vivo Langendorff-perfused human heart ventricles synchronously recording endocardial and epicardial surfaces under pacing-down restitution protocols. We analyzed the optical signals using a semi-automatic custom MATLAB algorithm to remove drift, reduce fluorescence-induced noise, normalize pixel-to-pixel, and evaluate a binary mask. A comparative spatiotemporal analysis of voltage alternans, conduction velocity, and characteristic spatial length linked with the normalized one was carried out for both types of tissues.

Results: Our analysis reveals a complex alternans pattern as pacing cycle length decreases, emphasizing differences in conduction velocity and spatial alternans patterns between tissues. We demonstrate how the spatiotemporal correlation analysis could summarize the classical features in one synthetic index, further highlighting synchronization patterns and providing information on the transmural heterogeneities in the human ventricle.

Conclusion: Our study provides new insights into the dynamics of the human epicardium and endocardium surfaces, as well as their differences in terms of spatiotemporal dynamics under pro-arrhythmic conditions. The study of quantitative indices, such as the decay length associated with CV and APD-restitution curves and spatial alternans maps, could provide critical implications in developing new therapies to prevent cardiac arrhythmias.