Title:

Investigation of the Arrhythmogenic Mechanisms of Atrial Tachycardia and Ventricular Fibrillation through Electrical Voltage Mapping Amplitude and Activation Optical Mapping in Isolated Rabbit Hearts.

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Cardiac arrhythmias are substrate-dependent conditions involving structural and electrical remodeling, as well as abnormalities in calcium handling. In this context, these alterations favor mechanisms such as rotors, reentry, and focal triggers. Current voltage mapping (VM) systems still lack universal cut-off thresholds, which limits precise substrate characterization. Therefore, this study uses an animal model to identify epicardial arrhythmogenic substrates by integrating VM with optical local activation time (LAT) maps.

Unipolar voltage cutoff values for healthy epicardial tissue were determined in isolated rabbit hearts (n = 9; 1,600 beats per chamber), perfused using the Langendorff system, based on the 95^{th} percentile of peak-to-peak amplitudes during sinus rhythm (SR). Arrhythmogenic substrates during atrial tachycardia (AT) and ventricular fibrillation (VF) were characterized by integrating epicardial electrical mapping with panoramic optical mapping. VM combined with optical (LAT) maps, was used to identify and classify substrates by analyzing optical LAT behavior specifically in regions corresponding to non-healthy tissue (NHT) — low-amplitude regions identified by VM — using voltage thresholds determined.

Characterization of the substrate undergoing AT, a reduction in global peak-to-peak amplitudes was observed between SR and AT (18.7±9.8 mV to 7.9±6.0 mV), accompanied by an increase in the percentage of NHT areas from 0% to 50%. These regions were localized, transient, and frequency-dependent, with LAT maps showing conduction slowing and increased isochronal line density. For VF, a more pronounced reduction in global amplitudes was observed between SR and VF (30.0±5.5 mV to 0.7±0.2 mV), along with an increase in NHT regions from 0% to 100%, persisting after the arrhythmia. LAT maps revealed, in these same regions, complex conduction patterns and slowing.

The integration of electrical VM with optical LAT mapping enables a more accurate and mechanistic characterization of arrhythmogenic substrates, allowing the differentiation between functional (AT) and structural (VF) alterations in cardiac tissue.