Digital Twins for Atrial Fibrillation Including Fibrosis Infiltration Characterized from Voltage Measurements

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Atrial fibrillation (AF) catheter ablation is associated with high recurrence rates. Personalized computational models, or digital twins (DTs), offer a framework to optimize these procedures through patient-specific ablation planning. Given its key role in arrhythmia maintenance, fibrosis characterization is essential for the predictive fidelity of these models.

We propose a methodology to estimate fibrotic distribution from intracavitary electrical recordings. Simulations of atrial tissue across varying fibrosis levels (0-35%) were conducted to generate endocardial bipolar electrograms and quantify the peak-to-peak voltage (Vpp). From these, a calibration function (R^2=0.94) was established to correlate Vpp with fibrotic burden.

This function was applied to clinical data from three patients to generate personalized substrate maps, differentiating healthy tissue (>0.25 mV), scar (<0.1 mV), and interstitial fibrosis. This methodology was integrated into our established workflow for electrophysiologically informed DTs, which are anatomically and functionally characterized to patient-specific biomarkers (cycle length and conduction velocity).

These models would enable the development of model-guided ablation strategies tailored to the individual structural characteristics of each patient.