Spatial Distribution of Repetitive Electrograms Identifies a Spectrum of Organization from Atrial Fibrillation to Flutter

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Background

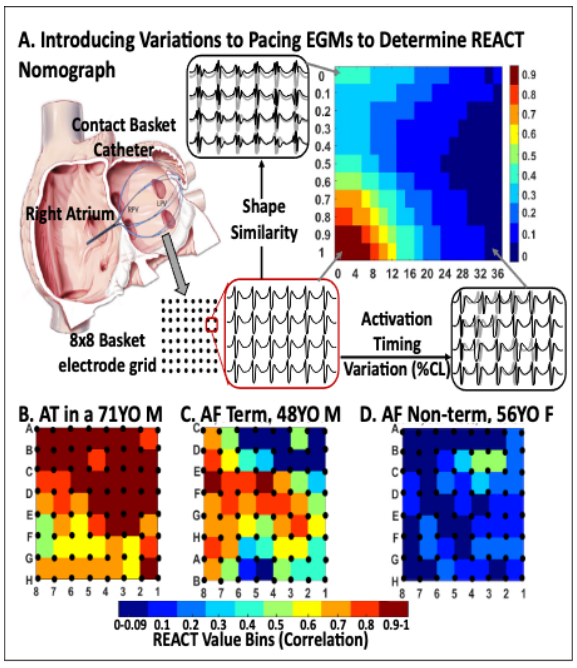
Atrial fibrillation (AF) may show regional organization in the frequency domain, in vectors, and in potential drivers, but tools used to map organization in AF are clinically non-intuitive and have low reproducibility between centers.

Objective

To test the hypothesis that a novel method to identify regions within which spatial electrogram (EGM) patterns repeat with a high correlation may serve as an effective tool for decoding organization in AF.

Methods

REpetitive ACTivity (REACT) mapping computes spatiotemporal correlation of unipolar electrograms (EGMs) at all 2x2 spatial grids from a 64 pole Basket catheter (Figure A). A REACT value indicates the *degree of repetition* (range: 0 to 1, 1=highest repetition) of activation timing and morphology (shape) within the recording window.



We systematically evaluated our algorithm to assess: (i) Function Nomograph: We introduced stochastic variations in activation timing (% cycle length) and shape (similarity to original shape) of EGMs recorded during clinical pacing (highly repetitive EGMs) to simulate decreasing levels of repetition (Figure A). We then applied REACT mapping on each of these simulated signals to determine the nomograph of REACT. We averaged the nomograph for N=100 trials of random values. (ii) Clinical significance: We recruited N=70 patients (age 63.0±10.1yrs, 67.6% male) in groups (I) N=10 patients with AT, (II) N=30 patients with AF that terminated by ablation, and (III) N=30 AF patients without termination. We applied REACT mapping offline to 4sec EGMs, and assessed the spatial distribution of repeating EGM islands in each of the 3 groups.

Results

Nomograph of REACT (Figure A) indicates highest value for pacing EGMs with minimal variations, which monotonically decreased for rhythms with increasing variation. For similarity<0.4, there were fewer unique signals. The calibrated nomogram was used to interpret the extent of variability present in our arrhythmia cases. Fig B-D illustrate patient examples from each group with islands of repeating EGMs (≥0.5 REACT). (B) In AT, the entire atrium shows high REACT scores (100%); (C) In AF that terminated, a spatial zone of high REACT values were present (67.4% of mapping field); (D) In AF that did not terminate by ablation there was little organization, with repeating EGM islands occupying only 4.1% of the atrium. Overall, areas of repetitive EGMs indicated a hierarchy of organization from patients with (I) AT (80.7±16.3% mapped field), to (II) AF that terminated (56.4±28.3%) then (III) AF that did not terminate (25.9±21.3, p<0.001).

Discussion

REACT is an intuitively plausible tool to quantify organization in human AF and AT. Future studies could use REACT to identify patients who may benefit most from ablation, and to gain mechanistic insights into AF phenotypes.