

Title: Atrial Arrhythmia Prediction Using Electrographic Flow Mapping Metrics

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ABSTRACT:

Background

When atrial fibrillation (AF) is organized whether by medication or ablation, it can become difficult to discriminate from atrial flutters (AFL) and tachycardias (AT). Electrographic Flow (EGF) mapping displays global atrial wavefront propagations in near real-time. Patterns of EGF can show regions of stable flow direction over time (electrographic flow consistency, EGFC) or disorganized electrical wavefronts (flow angle variability, FAV).

Objectives

Evaluate EGF patterns and metrics that may be used to successfully differentiate endocardial activations of various atrial arrhythmias.

Methods

From 183 patients who underwent EGF mapping with a 64-pole basket catheter, 3,030 one minute recordings were analyzed to establish independent metrics that varied most significantly across different atrial arrhythmias. Principal Component Analysis was used to visualize separability of an equal number of recordings in each rhythm using only the 4 most significant metrics. Classification performance was assessed using a 3 layer convolutional neural network (CNN) trained with a rectified linear activation function, categorical cross-entropy loss function, and Adam optimization algorithm. 64% of metrics were used for training, 16% for cross-validation, and the remaining 20% for testing and determining prediction accuracy.

Results

Mean EGFC, FAV, RR interval and a local disorganization score computed based on the maximum cross-correlation between consecutive pairs of RR intervals on each of 64 basket electrodes, were found to be the best metrics for discriminating among atrial arrhythmias (**A**). Mean EGFC and mean FAV varied the most between AF and AFL ($p=5.24 \times 10^{-19}$ and $p=5.37 \times 10^{-34}$, respectively) while disorganization score and mean RR interval varied the most between AF and AT ($p=5.32 \times 10^{-235}$ and $p=1.25 \times 10^{-7}$, respectively). The CNN was able to accurately determine the rhythm from previously unseen samples with 81% accuracy when given only these 4 metrics. It also was 100% successful at distinguishing all instances of AF from AT though there was some overlap between AFL and AT (**B**).

Conclusions

Summative EGF metrics that characterize vector flow provide signature patterns of global atrial wavefront propagations in different atrial arrhythmias that can be used to successfully discriminate these arrhythmias.

Figure: (A) The best metrics that most significantly differed among atrial arrhythmias. **(B)** No single metric alone can always discriminate endocardial activation patterns. Principal Component Analysis was used to successfully separate the 4-dimensional EGF components in 2D space.

