Defining the Predictive Ceiling of Electrogram Features Alone for Predicting Outcomes From Atrial Fibrillation Ablation

Background:
Prior studies have attempted to predict long-term outcomes from atrial fibrillation (AF) ablation using clinical variables, structural data and intracardiac electrograms (EGMs), but with modest results.

Hypothesis:
We hypothesized that explainable machine learning of a very large dataset of patients undergoing AF Ablation using : (1) PCA combined with clustering; (2) Auto regressive models combined with classifiers; (3) handcrafted features; from EGMs may reveal novel features that predict arrhythmia freedom after AF ablation.

Methods:
N=561 AF patients (65.0±10.4 yrs, 27.6% female) in whom unipolar EGMs were recorded at 64-sites. We developed 3 models, each probing different features of EGMs using 70%-30% split training/testing set:

1. PCA: Analyzing variances of PCA of eigenvector projecting more than a fixed threshold of the global variance (15%). We clustered eigenvectors to find common projection axis among them using k-means algorithm.
2. Auto Regressive: associated with a bijective transformation on the coefficients to use them as input for different ML Classifiers: Random Forest, SVC, AdaBoost, NB & LR.
3. Features Engineering: voltage, rate and shape similarity extracted from raw EGMs

Results:
N=390 had freedom from arrhythmia (AF and AT) for <1 year after blanking period ("Freedom" group, 69.5%), and N=171 had recurrence ("Recurrence" group).

1. Projected variance of EGMS in Recurrence and Freedom groups respectively is larger in Recurrence group than in Freedom group (37.5 ± 21.3% vs 29.5 ±15.9% of the global variance, p=0.21 for KS2).
2. AUC=0.71 with a Random Forest Classifier associated with Auto Regressive Processes of order 2 to predict long term outcomes
3. This was not improved by adding intrinsic electrogram features, with AUC=0.72 from raw EGMs.

Conclusions:
Exhaustive analysis of electrogram data in AF patients provides limited predictive value for outcomes from AF ablation. PCA-Clustering and AR-Classifier revealed features that predicted AF ablation outcomes with modest success.