

Mathematical Analysis of Atrial Spatiotemporal Complexity on Standard ECG for Catheter Ablation Outcome Prediction in Persistent Atrial Fibrillation

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Introduction.

Patient selection is a critical issue for improving results of radiofrequency catheter ablation (CA) of persistent atrial fibrillation (AF). Classical standard 12 lead ECG atrial activity (AA) parameters such as mean amplitude and cycle length were studied in a single lead, thus neglecting AA spatial variety and temporal evolution. We aimed to investigate the potential role of AA spatiotemporal variability in CA outcome prediction.

Methods.

One-minute 12 lead ECGs were acquired at the start of CA. Unlike single lead methods, we combine the normalized mean square errors (NMSE) between successive AA segments in the 8 independent leads of the standard ECG to quantify AA spatiotemporal diversity. Principal component analysis (PCA) estimates their rank-1 approximations and extracts the most descriptive AA components common to the leads retained. Mean NMSE values/lead are then weighted by their inverse variance into a pondered sum $\tilde{\mu}_1$, so emphasizing leads with more stationary AF. CA success is defined as freedom from ECG/Holter documented sustained AF recurrence (> 30 s) during follow-up.

Results.

We enrolled 20 patients (pts; 19 males, 60±11 y) with a median AF episode duration of 4.5 months (m; 2-84). After 1.15 procedures/pt and a median follow-up of 9.5 m (4-19), CA was effective in 13 pts (65%). Higher $\tilde{\mu}_1$ values suggest more organized and repetitive AA patterns and are significantly correlated with CA success, Table I. Prediction power is assessed by the area under the ROC curve (AUC) index. Our method is compared with results in V_1 for AA amplitude $D(V_1)$ and mean $(NMSE_{V_1})_1$.

Conclusion.

Our multilead parameter predicts more accurately CA outcome than standard single lead approaches.

Table I: CA result predictors

	Successful CA	Unsuccessful CA	<i>p</i> value	AUC	Best Cutoff
$\tilde{\mu}_1$ [%]	65.68 ± 19.27	37.59 ± 21.88	0.008	0.84	45.57
$(NMSE_{V_1})_1$ [%]	58.09 ± 23.49	80.40 ± 22.88	0.056	0.71	76.34
$D(V_1)$ [mV]	0.08 ± 0.03	0.06 ± 0.01	0.030	0.80	0.05