Catheter Ablation Outcome Prediction with Advanced Time-Frequency Features of the Fibrillatory Waves from Patients in Persistent Atrial Fibrillation

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Background and Aim. Despite its limited long-term success rate, catheter ablation (CA) is still the first-line treatment for patients suffering from persistent atrial fibrillation (AF). Preoperative prediction on the procedure's outcome is gaining clinical interest to provide optimized patient selection, limit repeated procedures, hospitalization rates and treatment costs. Considering that dominant frequency (DF) and amplitude of fibrillatory waves (f-waves) reflected on the surface ECG have provided better predictive abilities than many clinical features, this work explores a novel f-waves set of frequency and amplitude features aimed at improving preoperative outcome prediction of CA.

Methods. In addition to DF and normalized f-wave amplitude (NFWA), three indices combining information from time and frequency domains were analyzed. Spectral entropy (SE), spectral flatness measure (SFM), and amplitude spectrum area (AMSA) were computed from f-waves extracted from lead V1 by adaptive QRST cancellation. A total of 204 6 s-length ECG intervals were analyzed, which were extracted from 51 persistent AF patients undergoing radio-frequency CA. After 9 months of follow-up, 21 patients relapsed to AF and 30 maintained sinus rhythm (SR). Thus, the analyzed dataset was composed of 84 and 120 f-wave segments, respectively.

Results. Although all single indices reported statistically significant differences between both groups of patients, they obtained limited values of sensitivity (Se), specificity (Sp), and accuracy (Acc) ranging between 55 and 62% (see table below). Nonetheless, combination of NFWA, SE and AMSA through a linear discriminant analysis provided values of Se, Sp and Acc of 71.43, 82.73 and 77.84%, respectively, thus obtaining improvements of 10–18%.

Conclusions. Combination of frequency and amplitude features of the f-waves may provide new insights about the atrial substrate remodeling, and thus improve preoperative CA outcome prediction.

Index	SR group	AF group	p-value	Se (%)	Sp(%)	Acc(%)
DF (Hz)	6.01±1.47	6.44±1.25	0.048	57.27	57.14	57.22
NFWA (%)	6.47±4.45	5.14±2.98	0.040	55.45	57.14	56.12
SE (no units)	0.77±0.08	0.74±0.08	0.001	61.82	61.91	61.86
SFM (%)	37.07±13.92	32.62±13.86	0.012	59.01	63.10	60.83
AMSA (μV $\cdot$ Hz)	189.34±82.74	231.83±85.71	<0.001	58.18	63.10	60.31