Catheter Ablation Outcome Prediction in Persistent Atrial Fibrillation Based on Spatio-Temporal Complexity Measures of the Surface ECG

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Background: Radiofrequency catheter ablation (CA) is increasingly employed to treat atrial fibrillation (AF), yet selection of patients who would actually benefit from this therapy still remains an open issue.

Methods: The present work introduces some non-invasive quantitative parameters to discriminate between successful and failing CA procedures by exploiting the spatial diversity of the 12-lead surface ECG. They are based on the normalized mean square error (NMSE) between consecutive atrial activity (AA) ECG signal segments and their rank-n approximations determined by principal component analysis (PCA). As opposed to the single-lead approach of previous works, we consider NMSE values computed on more than one lead. In particular, the NMSE weighted mean $\overline{\mu_n}$ is obtained by weighing the average NMSE values by their standard deviations, whereas ${\mu_n}^{MIN\sigma}$ denotes the NMSE value associated to the lead characterized by the minimum standard deviation of NMSE values of ECG segments projections.

Results: The computation of the proposed parameters on an ECG database composed of 18 persistent AF patients (14 successful outcomes, 4 failing procedures) confirms that lower output values describe more organized AA waveforms and can be associated with procedural AF termination (Table I). Subscripts START, PV, END concern distinct CA phases, namely, the beginning, pulmonary vein isolation, and the end of the procedure, respectively. Their predictive accuracy is assessed by ROC analysis, yielding AUC = 0.77, p value = $1 \cdot 10^{-2}$ for $\overline{\mu_3}_{PV}$, AUC = 0.86, p value= $1 \cdot 10^{-5}$ for the other indices.

Conclusions: This study demonstrates that the proposed multilead parameters can effectively predict CA outcome and potentially contribute to more accurate patient selection strategies for this AF therapy.