

Tailored Lag Selection in Poincaré Analysis of f-Waves for Atrial Organization Assessment in Persistent AF

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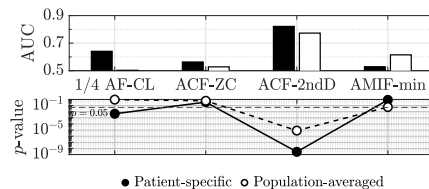
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Background and Aim. Poincaré plot (PP) analysis provides a nonlinear framework to characterize physiological signals. Nevertheless, PP application to atrial fibrillatory waves (*f*-waves) remains largely unexplored. As PP representations are highly influenced by the chosen lag, this study evaluates different lag-selection criteria and their impact on PP-derived descriptors for discriminating clinical outcomes in persistent atrial fibrillation (AF).

Methods. Preprocedural ECG recordings from 52 persistent AF patients undergoing catheter ablation (CA) were retrospectively analyzed. Up to three 6 s *f*-wave segments per patient were extracted from lead V1. Lag values were estimated using well-established criteria, including fractions of the dominant cycle length ($AFCL/4$), autocorrelation-derived measures, such as the first zero crossing ($AFC - ZC$) and the first sign change in the second derivative of the AFC ($AFC - 2ndD$), and the first local minimum of auto-mutual information function ($AMIF - min$). Patient-specific and population-averaged lags were determined and used as embedding delay to construct PPs. Standard ellipse-based PP descriptors were calculated and their capability to discriminate AF recurrence after CA was evaluated.

Results. Lag selection influenced PP-derived descriptors and their ability to discriminate between recurrence and non-recurrence groups. Tailored lag-selection criteria yielded improved discriminative performance compared to fixed population-based lag values. Among the evaluated criteria, $AFC - 2ndD$ yielded the strongest statistical significance across descriptors. The fitted ellipse axis ratio ($SD1/SD2$) was the most discriminative descriptor (p -value $< 10^{-8}$) and achieved the highest classification performance (AUC = 83.2%).

Conclusions. Lag selection is a critical factor in PP analysis of *f*-waves in persistent AF. Patient-specific strategies improved the predictive value of PP descriptors, supporting their potential as non-invasive markers for CA outcome prediction.



Comparison of $SD1/SD2$ performance for CA outcome prediction across different lag selection criteria.