Linear and Nonlinear Correlations Between Surface and Invasive Atrial Activation Features in Catheter Ablation of Paroxysmal Atrial Fibrillation

Aikaterini Vraka, Vicente Bertomeu-González, Fernando Hornero, Luca Faes, Raúl Alcaraz, José J Rieta

BioMIT.org, Electronic Engineering Department, Universitat Politecnica de Valencia, Valencia, Spain.

Background. Substrate modification due to catheter ablation (CA) of atrial fibrillation (AF) is extensively assessed by surface P-wave analysis, considering the atria as an entity. As coronary sinus (CS) is the key reference structure in CA procedures, it is important to elucidate if it follows similar patterns with P-waves, a so far unknown issue. This study aims to define correlations between P-waves and CS local activation waves (LAWs) features to study the relationship between surface and invasive atrial activations.

Methods. Duration, amplitude, area and slope rate were studied in P-waves and LAWs from five minutes recordings of 29 patients undergoing paroxysmal AF CA. Features were corrected by adjustment for heart rate (HR) fluctuations. Pearson's correlation (PC) was calculated between CA-induced variations of P-waves and LAWs features. Linear correlations between features of each P-wave and LAW were examined by PC and linear regression. Nonlinear correlations were investigated with cross-quadratic sample entropy (CQSE).

Results. Low or mediocre linear correlations were found for all PC tests ($\rho < 0.52$, $p < 0.025$ for statistically significant results) and linear regression analysis. For linear regression, with P-waves as response, only HR-adjusted duration showed a significant albeit low correlation ($R^2 < 23.94\%,\ p < 0.029$). Although notably more features showed statistically significant relationships with P-waves as predictors, these were quite low with the HR-adjusted duration being the highest ($R^2 < 16.32\%,\ p < 0.001$). CQSE values were between 0.8 and 1.3, also suggesting weak nonlinear relationships.

Conclusions. P-waves and LAWs are poorly linearly and nonlinearly correlated and do not describe to the same degree the substrate modification after CA. Adjustment for HR fluctuations slightly potentiates these relationships, which continue to be minimal. As P-waves correspond to depolarization of the entire atria and CS LAWs to more local information, it is possible that P-waves reflect the cumulative CA-induced modifications of various atrial sites, with CS being one of them but not the dominant.