A wavelet-based method for non-invasive dominant frequency detection in atrial fibrillation

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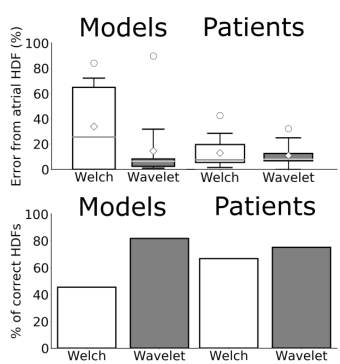
Objective: Atrial dominant frequency (DF) maps undergoing atrial fibrillation (AF) presented good spatial correlation with those obtained with the non-invasive body surface potential mapping (BSPM). In this study, a robust BSPM-DF calculation method based on wavelet analysis is proposed.

Approach: Continuous wavelet transform along 40 scales in the pseudo-frequency range of 3-30 Hz is performed in each BSPM signal using a Gaussian mother wavelet. DFs are estimated from the intervals between the peaks, representing the activation times, in the maximum energy scale. The results are compared with the traditionally widely applied Welch periodogram and the robustness was tested on different protocols: increasing levels of white Gaussian noise, artificial DF harmonics presence and reduction of number of leads. 11 AF simulations and 12 AF patients are considered in the analysis. For each patient, intracardiac electrograms were acquired in 15 locations from both atria. The accuracy of both methods was assessed by calculating the absolute errors of the BSPM highest DF (HDF) with respect to the atrial HDF, either simulated or intracardially measured, and assumed correct if ≤ 1 Hz.

Main results: The proposed method allowed an improvement on non-invasive estimation of the atria HDF (top of Figure, median relative error of 7.14% vs. 60.00%, p = 0.06), outperforming the Welch approach in correct estimations (bottom of Figure) for both models (81.82% vs 45.45%) and patients (75.00% vs 66.67%). The method was more robust to white Gaussian noise and harmonics and presented more consistent results in lead layouts with low spatial resolution (p = 0.99 vs. p = 0.94).

Significance: Estimation of atrial HDFs using BSPM is improved by the proposed wavelet-based algorithm, helping increase the non-invasive diagnostic ability in AF.



Errors between BSPM and atrial HDF (top) and percentage of correct detections (bottom) in each method