

Time-frequency analysis of atrial fibrillation comparing morphology-clustering based QRS-T cancellation with blind source separation in multi-lead surface ECG recordings

Luigi Y Di Marco*, Susan King, John Bourke, Lorenzo Chiari, Alan Murray, Philip Langley

DEIS

University of Bologna, Bologna, Italy

INTRODUCTION: To separate the atrial (AA) from the ventricular (VA) electrical activity in surface ECG recordings of atrial fibrillation (AF), various methods have been proposed, such as QRS-T cancellation by averaged complex subtraction, and blind source separation (BSS). Although QRS-T cancellation is computationally more efficient than BSS, it is sensitive to morphology changes, which produce large residuals in AA, biasing the frequency analysis. **OBJECTIVE:** To present a morphology-clustering based approach to QRS-T cancellation, and to compare the time-frequency distribution of the obtained AA signal (KM-AA) with the one obtained from an established BSS method based on independent component analysis (ICA-AA). **METHODS:** Twelve AF recordings (2 minutes) of multi-lead surface ECG (64 thoracic: CL1, CL64, three bipolar limb leads) were considered. For each thoracic ECG channel individually, QRST morphologies were grouped by k-means clustering. KM-AA was obtained by subtracting for each beat the corresponding QRST morphology (cluster centroid) from the ECG. ICA was computed from a subset of 6 channels (3 bipolar limb leads, CL4, CL12, CL20). ICA-AA was calculated as the independent source with minimum kurtosis. Short-time Fourier transform (STFT) time-frequency analysis was performed on ICA-AA and the 64 KM-AA signals. For each recording, the dominant AF frequency was computed in the range of interest (5-10 Hz), for each time slot (4 s). Results were compared for KM-AA for CL20 (approximately corresponding to V1) and for ICA-AA. **RESULTS:** Effective VA suppression was obtained by KM-AA: residual QRS-T segment peak-to-peak amplitude (84.0 ± 27.1 microVolt) was not significantly different (Kruskal-Wallis, $\alpha=0.01$) from ECG TQ segment (98.6 ± 18.1 microVolt). Inter-recording dominant AF frequency estimation difference (KM-AA vs. ICA-AA) was not significant (Kruskal-Wallis, $\alpha=0.01$) in 11 of 12 recordings. **CONCLUSIONS:** The proposed QRS-T cancellation method effectively suppresses VA and accurately estimates time-frequency distribution of AF, compared to an established BSS method.