Stationary Wavelet Transform for Extraction of the Impedance Circulation Component During Out-of-hospital Cardiac Arrest

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Introduction: There is still a need for an automated method for pulse detection during out-of-hospital cardiac arrest (OHCA). The thoracic impedance (TI) recorded through defibrillation pads presents an impedance circulation component (ICC), often hidden among other components, in the form of small fluctuations correlated with each effective heartbeat. The aim of this study was to develop a method based on the stationary wavelet transform (SWT) to derive the ICC.

Materials and methods: The dataset contained 456 5-s segments with concurrent ECG and TI signals collected from 49 OHCA patients treated by Tualatin Valley Fire & Rescue (Tigard, OR, USA) in 2012. The ECG corresponded to organized rhythms without cardiopulmonary resuscitation artifact: 281 pulseless electrical activity (PEA) and 175 pulse-generating rhythms (PRs). The SWT was used to decompose the TI into 7 levels using a biorthogonal 4.4 mother wavelet. The ICC was derived from soft denoised $d_6 - d_7$ (0.78-3.13 Hz band) or d_7 (0.78-1.56 Hz band) detail coefficients for segments with heart rate $\geq$93 bpm (1.56 Hz) and $<$93 bpm, respectively. Six features characterizing the amplitude and area of the ICC and its first derivative (dICC) were calculated. Their PEA/PR discrimination power was measured using the area under the curve (AUC) of the Receiver Operating Characteristic Curve analysis. These AUC values were compared with those obtained for the same features derived from the ICC/dICC extracted using an adaptive recursive least-squares (RLS) algorithm.

Results: The six features showed great discriminative power with a mean (SD) AUC of 0.91 (0.03) while RLS-based features yielded a mean AUC of 0.85 (0.07). The AUC of every single feature was higher than its analogous in RLS-based method.

Conclusion: The ICC can be reliably extracted using a SWT-based method. Combining these ICC/dICC features with ECG features in a machine learning classifier might result in a robust pulse detector.