A Machine-Learning based Pulse Detection Algorithm for Use during Cardiopulmonary Resuscitation

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Introduction: Resuscitation guidelines mandate pausing chest compressions during cardiopulmonary resuscitation (CPR) to check for the presence of pulse. However, interrupting CPR during a pulseless rhythm adversely affects survival. The aim of this study was to develop a pulse detection algorithm during CPR using the electrocardiogram (ECG) and thoracic impedance (TI) signals.
Materials: Data from three emergency services were used (London, Stockholm and Akershus), comprising 116 out-of-hospital cardiac arrest patients. A total of 429 segments, 290 pulseless electrical activity (PEA) and 139 pulse-generating rhythm (PR), were analyzed. Each segment comprised 15.5-s long ECG and TI signals recorded during CPR, from which 3-s corresponded to an interval without chest compression artifacts.
Methods: CPR artifacts were first removed from ECG and TI using recursive least-squares (RLS) filters. The impedance circulation component (ICC) was then derived from the filtered TI using a RLS-based adaptive scheme. The wavelet decomposition of the ECG and ICC was carried out to obtain the different subband components and the denoised ECG and ICC. A total of 127 PR/PEA discrimination features were extracted from those signals and fed into a random forest (RF) classifier that made the pulse/no-pulse decision. A repeated nested cross-validation procedure was used for feature selection, parameter tuning, and model assessment.
Results: The method showed a mean (standard deviation) sensitivity (pulse), specificity (no pulse) and balanced accuracy (BAC) of 76.2% (3.0), 66.2% (3.4) and 71.2% (1.7). The BAC was only 4-points below the performance of the RF classifier during artifact-free intervals. Furthermore, adding TI-features to a model based exclusively on ECG-features yielded a BAC improvement of 0.7-points.
Conclusion: A novel ECG and TI based algorithm showed potential to improve resuscitation by detecting pulse during CPR.