ECG Rhythm Analysis during Manual Chest compressions using an Artefact Removal Filter and Random Forest Classifiers

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Introduction: Chest compression (CC) artifacts during cardiopulmonary resuscitation (CPR) make ECG rhythm diagnosis during CPR unreliable in current defibrillators.

Aim: To develop a reliable shock advice algorithm (SAA) for use during manual CCs to minimize interruptions in CPR.

Materials: Data from three emergency services were used (London, Stockholm and Akershus), comprising 273 out-of-hospital cardiac arrest patients. 2203 ECG segments recorded during CPR were extracted and labeled as shockable (506) or non-shockable (1697).

Methods: CPR artifacts were removed using a recursive least-squares (RLS) filter. Two filter configurations were tested, fine (λ_1=0.987) and coarse (λ_2=0.998) filtering. For each filtered ECG over 200 shock/no-shock decision features were computed and fed into a random forest (RF) classifier. For each classifier the best 25 features were selected through out-of-bag error ranking procedure. The results of the two RF-classifiers were further combined using a meta-classifier. 10-fold cross-validation was used for model assessment, and statistical distributions of sensitivity (Se) and specificity (Sp) were obtained replicating the process 100 times. Results were compared to a state-of-the art multistage method (MSA) that uses two RLS-filters (λ_1 and λ_2) and the SAA of a commercial defibrillator in three decision stages.

Results: The mean (95% confidence interval) Se and Sp of the proposed algorithm were 93.5% (92.9-94.1) and 96.5% (96.2-96.7), respectively. The Se and Sp of the state-of-the art MSA solution were 91.7% and 93.7%, far below those obtained using the meta-classifier. Moreover, the proposed algorithm meets the minimum 90% Se and 95% Sp performance goals recommended by the American Heart Association (AHA).

Conclusions: An AHA compliant method for rhythm analysis during manual CCs has been developed which considerably improves the performance of currently available methods.