Adaptive filtering methods for ECG waveform restoration during cardiopulmonary resuscitation.

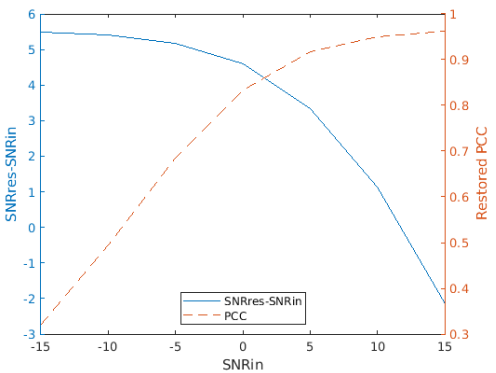
Alvaro Iza[1], Andoni Elola[1], Iraia Isasi[1], Elisabete Aramendi[1], Trygve Eftestøl[2], Jo Kramer-Johansen[3] and Lars Wik[3]

University of the Basque Country, UPV/EHU, Bilbao, Spain[1]

Introduction: An artefact-free ECG is essential during out-of-hospital cardiac arrest (OHCA) to decide shock/no-shock therapy or any other therapy during cardiopulmonary resuscitation (CPR). Chest-compressions (CCs) cause artefacts that alter the ECG. This study analyzes the effectiveness of CPR artefact suppression filters to restore the ECG.

Materials and methods: Artificial mixtures of artefact-free ECGs (from public Holter recordings) and CPR artefacts obtained during asystole from an OHCA database were used. In total, 268 (67 patients) 8-second clean ECGs including ventricular fibrillation and organized rhythms, and 1192 8-second CPR artefacts (272 patients) were mixed at 7 controlled input signal-to-noise ratios (SNRin) ranging from -15 dB to 15 dB. Each clean ECG was mixed with 15 randomly selected CPR artefacts at 7 SNRin values resulting in a database of 28140 segments. Three filtering methods were used: LMS (Least-Mean-Square), Root-mean-Square and Kalman. Different number of harmonics (N) and many adaptability coefficients were tested for each filter (λ, μ, q). The best filter was selected in terms of the mean restored SNR (SNRres) obtained for the range of all SNRin values for the best filter configuration. This filter was further analyzed in terms of the mean value of the Pearson's correlation coefficient (PCC) and SNRres after filtering.

Results: RLS was the best option with a mean SNRres of 3.3 dB at the optimal working point (N=2/λ=0.9994), slightly above the LMS algorithm (3.2 dB). At high corruption levels (up to -5 dB) the SNR increase was above 5 dBs (see Figure). The similarity of the restored and the clean ECG increased with SNRin, obtaining PCC values above 0.6 for SNRin> -5 dB (see Figure).



Conclusion: A suitable filtering method to restore ECG waveforms during CPR was proposed, that would enhance the reliability of the ECG analysis during CCs.