Filtering the Cardiopulmonary Resuscitation Artifact: An Analysis of the Influence of the Signal-To-Noise Ratio in the Accuracy of the Shock Advice Algorithm

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A reliable diagnosis by automated external defibrillators (AED) during cardiopulmonary resuscitation (CPR) would avoid unnecessary hands-off time, thus increasing the resuscitation success. In the last decade, several filtering techniques have been proposed to remove the artifact induced on the ECG during CPR. The improvement of the signal-to-noise ratio (SNR) has been frequently used to test CPR cancellation filters, using artificial mixtures of ECG signals and CPR artifact. In this work, we analyze the correlation between the diagnostic results of an AED after filtering with the input SNR of the corrupted ECG, for real out-of-hospital resuscitation episodes. We processed 381 ECG records, 89 shockable and 292 non-shockable (88 asystole and 204 non-asystolic rhythms). Each record contains an initial 15.5 s interval corrupted by CPR, followed by 15.5 s free-of-artifact. The CPR artifact was suppressed using a Kalman filter and we evaluated the sensitivity and the specificity of a commercial AED. The mean input SNR for the shockable and the non-asystolic records was -1.7 $\pm$ 6.8 dB and -0.6 $\pm$ 7.8 dB, respectively. There were 52 shockable records correctly classified before and after filtering with an input SNR of 1.3 $\pm$ 5.6 dB, and 32 shockable records that changed from non-shockable to shockable after filtering, with an input SNR of -4.3 $\pm$ 6.0 dB. Therefore, the sensitivity improved from 58.4% to 94.4%. The specificity for the non-asystolic group (92.6 %) did not change after filtering; there were 178 records correctly classified before and after filtering (SNR -0.6 $\pm$ 7.8 dB); 11 records were recovered as non-shockable (SNR -3.2 $\pm$ 5.6 dB) but 11 records initially classified as non-shockable were misclassified after filtering (SNR -8.0 $\pm$ 8.0 dB). The specificity for asystole decreased from 86.4% to 81.8%. We present the first estimation of the distribution of input SNR for out-of-hospital resuscitation episodes. Filtering is positively correlated with the sensitivity for low input SNR. Non-asystolic records with low input SNR are prone to be misclassified, while those with high input SNR are recovered after filtering. The total specificity worsened after filtering, due to asystole misclassifications.