Shock Advisory Neural Network for Continuous Detection of Ventricular Fibrillation, Organized Rhythm and Asystole during Cardiopulmonary Resuscitation

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Out-of-hospital cardiac arrest (OHCA) is a critical medical emergency that requires immediate intervention through cardiopulmonary resuscitation (CPR). Concomitant use of automated external defibrillators (AEDs) requires a shock delivery with minimal hands-off pauses. Advanced AED shock advisory systems (SAS) analyze the electrocardiogram (ECG) during chest compressions (CC). Nevertheless, confirmatory stage in hands-off pauses is also mandatory in 30-100% of cases. This study aims to develop SAS algorithm for continuous rhythm analysis during CPR, expanding beyond the conventional binary decision (shock, no-shock) to a ternary decision model (ventricular fibrillation-VF, organized rhythm-OR, asystole-ASYS). This approach aligns with different resuscitation actions for each rhythm: VF (shock), ASYS (continue CC), OR (pulse check).

This study uses CPR-contaminated ECGs derived from 2838 OHCA interventions with commercial defibrillators (DGT7, Schiller Médical, France), including a total of 13,570 regular AED SAS analyses (training/test): VF (409/393), OR (2151/2025), ASYS (4613/3979). ECG episodes during CPR (CPR-ECG) are considered up to 30s before AED analysis; ECG episodes during artifact-free ECG (clean-ECG) last 10s after AED analysis. A SAS deep learning model for ECG rhythm analysis during CPR is trained in one-second sliding mode, without preconditions based on the presence of chest compressions. The model employs a 3-layer convolutional architecture with two stages for unsupervised feature extraction in 10-second ECG, inferring VF probability in first-stage and OR/ASYS probabilities in second-stage.

The true positive rate of SAS with a ternary output in the test-set (clean-ECG, CPR-ECG) is: VF (98.7%, 94.4%), OR (91.7%, 72.4%), ASYS (95.2%, 81.5%). Major OR false negatives – FNs (7.3%, 24.8%) are agonic and ventricular escape rhythms, detected as ASYS. Inversely, major ASYS FNs (4.5%, 12.6%) are OR. Nevertheless, these errors do not affect SAS specificity. With VF sensitivity (98.7%, 94.4%), OR specificity (99%, 97.2%) and ASYS specificity (99.7%, 94%), the presented SAS algorithm provides competitive performance during CPR.

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