A method to detect pauses for ventilation during cardiopulmonary resuscitation using the thoracic impedance

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Background and aim: The recommended cardiopulmonary resuscitation (CPR) mode before intubation in out-of-hospital cardiac arrest (OHCA) is 30:2, 30 chest compressions followed by a pause for 2 ventilations. Effective ventilations are key for OHCA survival. CPR events can be observed in the thoracic impedance (TI) signal. This study proposes an impedance based method to automatically detect pauses in compressions during CPR.

Materials: Records from 102 OHCA patients acquired with a monitor/defibrillator and provided by the Dallas Fort-Worth Center for Resuscitation Research were used. A total of 1936 min of TI in the preintubation phase were reviewed, with a median(Q1-Q3) duration of 14(10-25) min. In total 1720 pauses were annotated, 13(9-19) per patient with a median duration of 6.06(4.65-8.19) s.

Methods: The TI was segmented into consecutive 1-s segments, 10 signal features were computed per segment, and fed to a Random Forest (RF) classifier to discriminate segments with compressions (positive class) and without compressions (negative). The classifier was validated using patient-wise 10-fold cross validation, and its performance characterized using the sensitivity (SE), specificity (SP), positive predictive value (PPV) and area under the curve (AUC). The classifier output was used to identify pauses with durations between 3 and 15-s, and the SE/PPV and interval delineation accuracy of the pause detector were evaluated.

Results: They were 92604 1-s segments (67% with compressions). The classifier had an AUC of 99.3(98.6-99.7)%, and SE/SP/PPV of 95.4(91.7-97.9)/97.5(95.6-98.6)/93.8(89.2-97.2)%. The pause detector had a SE/PPV of 91.7(81.7-100)/89.5(76.4-100)%, with a delineation error of 0.04(0.02-0.65)s for the start of the pause and 0.04(0.01-1.22)s for its duration.

Conclusions: An algorithm based on the TI was designed to detect the pauses for ventilation in the preintubation phase of CPR. This algorithm will contribute to a better characterization of CPR patterns, and a more accurate detection and characterization of ventilations during CPR.