Automated detection of pulse using continuous invasive arterial blood pressure in patients during cardiopulmonary resuscitation

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Introduction: Continuous invasive arterial blood pressure (ABP) is widely used to monitor the cardiovascular system. Cardiac arrest patients who achieve restoration of spontaneous circulation (ROSC) demonstrate an organized ECG. Invasive ABP has been proven to be useful to guide therapy during resuscitation and after ROSC. However, current ABP algorithms are not designed for CPR scenarios. The aim of the present study was to develop automated algorithms to detect pulse and measure physiological ABP variables in patients during CPR.

Materials and methods: Continuous invasive ABP (radial cannulation) and the ECG signal (LifePak15 defibrillator) were recorded by the physician manned rapid response car of the Oslo Emergency Medical System in patients during out-of-hospital CPR. A total of 122 segments of invasive ABP (mean duration 2.15±5 min, total duration 262 min) were extracted from 26 patients with regular ECG. The systolic/diastolic instants and pressures of each beat were manually annotated to be used as gold standard.

The ABP was denoised using an 8-level stationary wavelet decomposition (sampling frequency 250Hz) and a Daubechies-4 mother wavelet. Systolic peaks were detected using adaptive thresholding in the denoised ABP, and the systolic/diastolic and pulse pressures, and the heart rate were computed. The Sensitivity (Se), Positive Predictive Value (PPV) and F1-score (F1) of the method for systolic peak detection were calculated.

Results: The algorithm showed median (IQR) Se/PPV/F1 of 97.6 (17.5)/99.3(10.0)/97.2(10.1)% for systolic peak detection, 4-points above the F1 obtained with the wabp algorithm from Physionet. The absolute/relative errors were 0.62(1.40)mmHg/1.22(1.62)%, 0.74(1.43)mmHg-1.81(2.76)%, 1.13(1.67)mmHg/4.68(4.86)% and 0.50(1.42)min-1/0.58(1.31)% for systolic pressure, diastolic pressure, pulse pressure and heart rate, respectively.

Conclusions: An automated method to detect pulse in the invasive ABP signal during CPR was developed and tested. The precision of the measured variables supports the use of invasive ABP to guide CPR.