Detection of a spontaneous pulse by photoplethysmography during experimental automated cardiopulmonary resuscitation

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Introduction

Detecting return of spontaneous circulation (ROSC) during cardiopulmonary resuscitation (CPR) typically involves pulse checks by palpation. Palpation requires interruption of chest compressions. Because palpation is challenging and time-consuming, interruptions can be long, which adversely affects CPR outcome.
Here we propose photoplethysmography (PPG) to support ROSC detection and reduce interruptions in compressions. We developed an algorithm to obtain a compression-free PPG signal which estimates the spontaneous pulse waveform.

Methods

On ten pigs, automated CPR was performed in series of 30 compressions at 100 min^{-1}, alternated by two ventilations. We measured a reflective infrared PPG signal on the nose, trans-thoracic impedance (TTI) between the defibrillation pads, and aortic blood pressure.
The compression-free PPG signal was obtained by subtracting the compression component which was modelled by a harmonic series. For each compression, the fundamental frequency of the series was the compression rate derived from the TTI signal. A least mean-square algorithm estimated the amplitudes of the harmonics.
Algorithm performance was quantified during cardiac arrest by the percentage of reduction in root mean-squared (RMS) amplitude of the compression component. The RMS amplitude was determined per series of compressions.

Results

A compression rate of 99.9 ± 1.7 min^{-1} was accurately derived from the TTI signal. The compression component was effectively reduced by 79% ± 9%, such that the compression-free PPG signal showed absence of a spontaneous pulse during cardiac arrest.
Seven out of ten animals achieved ROSC. The compression-free PPG signal showed presence of a spontaneous pulse in these animals, provided that spontaneous pulse rate and compression rate were different.

Conclusion

Reducing the compression component in a PPG signal is feasible during automated CPR. The compression-free PPG signal can show absence or presence of a spontaneous pulse during compressions, which can support ROSC detection.