CPR Artifact Removal for Providing Continuous Heart Rate Recovery Procedure

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The procedure for cardiopulmonary resuscitation consists of sequential chest compression with mechanical ventilation and defibrillation. Standard resuscitation guidelines implies that there is a pause between compression and defibrillation of a few tens of seconds aimed at the heart rate evaluation and charging the defibrillator. Studies done on laboratory animals shown that this pause reduces the survival probability during sudden cardiac arrest [1]. A similar conclusion was reached by analyzing the clinical data obtained using the automatic external defibrillator [2]. In this regard, it is perspective to eliminate the pause during cardiopulmonary resuscitation, that involves evaluating the heart rate and charging the defibrillator during chest compressions and mechanical ventilation. Solution of this problem is a top priority and requires further research in order to detailed study of influence of compression artifact on the ECG signal.

Compression and mechanical ventilation are the main reasons for the occurrence of artifacts in the ECG signal during the procedure of cardio-pulmonary resuscitation [3]. Moreover, in case of ventricular fibrillation, the human heart is twitching at frequencies that match the characteristic frequencies of compression noise and determined by the frequency of chest compressions [4]. Also signals are generated as a result of direct impact on the chest and intrathoracic structures and by shrinking the pectoral muscles [3]. Signal processing algorithm must take into account some of technical features of the cardiopulmonary resuscitation procedure [5]:

- In case of real emergency situation, frequency and depth of chest compressions and mechanical ventilation are not constant over time.
- Compression artifacts are not sinusoidal in general, and they can contain high frequencies.
- A shape of compression artifacts can change over time.
- The relation between chest compression and ECG signals may vary over time, leading to changes in amplitude of compression artifacts.

Nowadays there are two directions of research aimed at reducing "hands-off" interval:

- Development of techniques for chest compressions artifact reduction in order to make possible the use of existing algorithms for the ventricular fibrillation detection. For example, the use of adaptive Kalman filtering [6] or a combination of different filter algorithms using delayed copies of the reference signal [5].
- Development of new algorithms for detecting ventricular fibrillation with reliance on the parameters that depends on the compression noise in ECG signal in a small degree [7].

Unfortunately, in spite of the fairly good results, the use of the algorithms above is not feasible in a real practice due to a poor parameters of sensitivity and specificity in the aggregate. In what follows, a detailed study of this problem is a perspective. It is planned an analysis of larger spectrum of filtering algorithm, the use of different reference signals such as the thoracic impedance or a blood pressure signals. It's possible to study of dependence between reference signal and ECG recorded with unipolar channels in addition to the classic bipolar. Also it's possible to evaluate the algorithm by using the filtered ECG as a test signal.

References

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