Estimating Heart Rate Turbulence from a Single Ectopic Beat with Robust Processing

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Heart Rate Turbulence (HRT) is defined as the increase and subsequent deceleration of the heart rate after a Premature Ventricular Complex (PVC). Current HRT measurements require a number of PVC which is not always present in all the patients, and more, it is unclear whether the averaging of turbulence in different PVC masks physiological changes instead of just cancelling noise.

Background

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Hypothesis

Efficient cancellation of physiological noise from each isolated Post-PVC Tachogram (PPT) will allow the quantification of HRT in a higher number of patients.

Methods

PPTs were recorded:
(a) In 10 patients during Electrophysiological Study (EPS), which were used as gold standard (patient in rest, with low electrophysiological noise);
(b) In 61 patients with post-myocardial infarction with 24-hour Holter monitoring.

PPTs were extracted according to conventional procedures in all cases. A robust algorithm for denoising the PPT was developed based on Support Vector Machine (SVM) interpolation, and optimized to work with a low number (15) of time samples, still avoiding overfitting.

Three different filtering methods were compared for each isolated PPT: Finite Impulse Response (FIR) filter, median filter, and nonlinear SVM-based filter.

Conclusion. It is possible to obtain time-local HRT measurements without averaging, by using robust digital signal processing. This allows us to measure the HRT in patients with Holter, even with a low number of PVC.

Results. Filtered PPTs exhibited the behaviour that is expected from the HRT physiological definition. Qualitatively, there was an excellent agreement between the EPS oscillations and the Holter-denoised PPTs. Quantitatively, for each patient we obtained the following sequence: first minimum, first maximum, and second minimum, for the raw and for the filtered PPTs. This provides a measurement of the similarity between the turbulence waveform and the postulated mechanism in the HRT definition (deceleration, acceleration, and oscillation). A significant increase (*p<0.001, paired t-Student when compared with unfiltered tachograms) was observed in the number of beats container between both minima, as shown in the table.