

Force-interval Relationships of the Heart Measured with Photoplethysmography during Atrial Fibrillation

Linda M. Eerikäinen^{1,2}, Alberto G. Bonomi², Lukas Dekker^{1,3}, Fons Schipper², Rik Vullings¹, Ronald M. Aarts^{1,2}

¹Eindhoven University of Technology, Eindhoven, The Netherlands

²Philips Research, Eindhoven, The Netherlands

³Catharina Hospital, Eindhoven, The Netherlands

Background: Force-interval relationships (FIRs) of the heart represent the relationships between inter-beat intervals (IBIs) and strength of the ventricular contraction. FIRs are typically measured invasively and are different in patients suffering from heart failure (HF) compared to subjects with non-failing hearts. In atrial fibrillation (AF), beat-by-beat variations in left ventricular function are partly influenced by FIRs. An unobtrusive continuous measurement of FIRs could be beneficial when AF and HF coexist because AF can cause further progression of HF. Signs of alteration in FIRs could indicate deterioration in the patient's condition. We hypothesize that FIRs could be assessed during AF with IBIs and hemodynamic changes captured unobtrusively by photoplethysmography (PPG) at the wrist, assuming a stronger correlation between them during irregular rhythms.

Methods: FIRs were assessed by measuring the relationships between the pulse onset change in the PPG waveform and either the preceding or pre-preceding IBIs as analyzed with Spearman's rank correlation (r_{pre} and $r_{pre-pre}$). 32 patients (14 continuous AF, 18 sinus rhythm) were measured during the night with PPG and electrocardiography as a reference. The correlation coefficients were calculated in 5-minute segments over the measurement period. Receiver Operating Characteristics (ROC) were analyzed in order to understand to which extent the correlations r_{pre} and $r_{pre-pre}$ were different during AF and sinus rhythm.

Results: The mean and standard deviation of r_{pre} were -0.25 ± 0.08 and 0.05 ± 0.12 ($p < 0.0001$), and of $r_{pre-pre}$ 0.60 ± 0.09 and 0.16 ± 0.14 ($p < 0.0001$), during AF and sinus rhythm, respectively. Areas under the ROC curve were 0.987 and 0.998, respectively.

Conclusion: FIRs could be unobtrusively assessed using wrist-PPG by IBI and morphology analysis of the PPG waveform. This will provide a novel parameter to study further with the aim of improving disease management for patients with coexistence of AF and HF.