Optimized Blood Pressure Classification by Features of Pulse Rate Variability and Asymmetry

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Aims: Pulse-rate variability (PRV) is gaining popularity over heart-rate variability (HRV) analysis. Among the wide spectrum of applications, PRV is used to monitor blood pressure (BP), a so far merely HRV task. While the suitability of PRV for BP estimation is still under dispute, the reported results suggest that there is room for improvement. This work aims to optimize the BP classification in critically-ill patients using verified PRV analysis.

Methods: Five-minute electrocardiography (ECG) and photoplethysmography (PPG) recordings of 202 critically-ill patients from the MIMIC-II database were recruited and classified into normotensive (NT), prehypertensive (PHT) and hypertensive (HT) according to BP values. PRV and asymmetry analysis was performed using time-, frequency-domain and non-linear indices. HRV analysis was used in order to verify the results using Bland-Altman (BA) and correlation analysis. Multi-class and single-class classification was performed using PRV and asymmetry features by kNN and SVM classifiers, setting a 10-fold cross-validation and a 20% test set.

Results: For all but NT-related groups, correlation was high ($\rho \geq 0.8$, $p < 0.05$) for all PRV/HRV features except for LF/HF. Correlation in asymmetry was low/moderate ($\rho_{max} \leq 0.77$, $p < 0.05$). BA analysis suggests a high concordance between all PRV and HRV features and asymmetry but LF/HF, SD1/SD2, Guzik (GI) and Porta index (PI) (confidence interval $> 90\%$, BA ratio $< 10\%$). Multi-group classification accuracy was up to 95% using SD of normal-to-normal interval (SDNN), variance of NN (VARNN), pnn50, low (LF) and high-frequency (HF), SD1 and PI. HT detection accuracy was 92.5% using the mean NN, RMS of SD of NN (RMSSD), very LF (VLF), LF and SD2. NT classification accuracy was 95% using median NN, SDNN, VLF, SD2, SD1/SD2, PI and GI.

Conclusions: PRV is reliable in monitoring BP in critically-ill patients. Adding pulse-rate asymmetry to PRV analysis significantly improves the results and outperforms previous studies applying PRV for BP estimation using the same database.