Characterization of Impaired Ventricular Repolarization by Quantification of QT Delayed Response to Heart Rate Changes in Stress Test

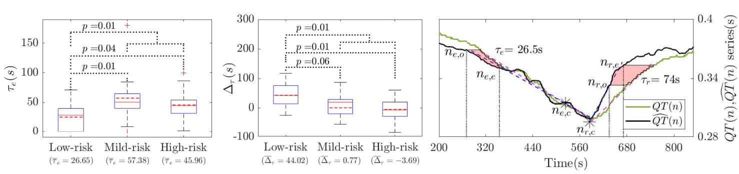
Cristina Pérez*, Esther Pueyo, Juan Pablo Martínez, Jari Viik, Pablo Laguna
BSICoS Group, I3A, IIS Aragón, University of Zaragoza, Spain.

Motivation and aim: The adaptation time of the QT interval to sudden abrupt heart rate (HR) changes modeled as a first-order system response is an ECG marker to stratify patients for arrhythmic risk. In such a first-order model, this time constant, τ, is the same as the delay in responding to a ramp-like HR change. Thus the time lag between the actual QT series and the expected memoryless HR-dependent QT series can be estimated from the exercise and recovery phases, being more feasible than from sudden step-like HR changes.

Materials: 39 stress test ECG recordings were selected from FINCAVAS study and divided into three groups, according to their likelihood for Coronary Artery Disease (CAD): low-risk, mild-risk and high-risk patients.

Methods: The memoryless expected HR-dependent QT interval time series, $\widehat{QT}(n)$, was calculated by fitting four regression models to $[QT(n), RR(n)]$ data pairs in three stationary QT-to-RR dependent windows. The time lag, τ^*, was estimated by a Mean Square Error fit between real $QT(n)$ and estimated $\widehat{QT}(n-\tau^*)$ ramps, separately in exercise, τ_e, and recovery, τ_r, phases.

Results and conclusion: The hyperbolic model provided the best fitting, and therefore, the selected one. The average time lags for exercise and recovery phases ($\overline{\tau}_e = 26.65s$ and $\overline{\tau}_r = 69.97s$, respectively, in the low-risk group) are in line with those of a previous study estimated from step-like HR changes in daily activities ($\overline{\tau}_e = 34.79s$ and $\overline{\tau}_e = 48.40s$). Results show that the delay τ_e increases with CAD risk; whereas the difference, Δ_τ, between delays τ_e and τ_r is remarkably larger for low-risk patients, being much reduced when CAD risk increases. Interestingly, the delay τ_r manifests a significantly reverted behavior. In conclusion, the proposed markers τ_e, τ_r and Δ_τ show potential for CAD risk stratification.



Box plots for τ_e and Δ_τ results, whose mean values are included at horizontal axis and with dashed line at the plot. On the right panel, an example of real QT(n) and memoryless expected HR-dependent QT time series with their corresponding exercise, τ_e, and recovery, τ_r, delays.