Model-Based Estimation of Electrocardiographic QT Interval from Phonocardiographic Heart Sounds in Healthy Subjects

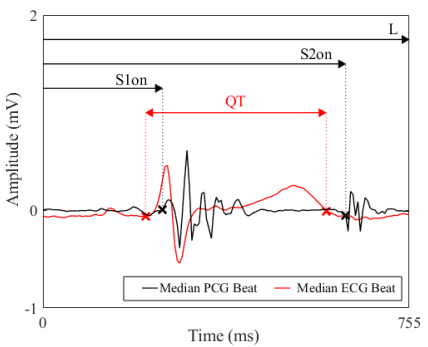
Agnese Sbrollini, Micaela Morettini, Ilaria Marcantoni, Laura Burattini

Università Politecnica delle Marche
Ancona, Italy

The electrocardiographic QT interval, representing the time duration of ventricular depolarization and repolarization, is a very commonly used index of cardiac electrical risk. However, QT measure is challenging in noisy conditions, when cardiac monitoring through phonocardiography may result easier. Phonocardiography is the recording of the S1 and S2 heart sounds representing the closure of cardiac valves. Being mechanical heart activity driven by its electrical activity, electrocardiogram (ECG) and phonocardiogram (PCG) are strictly related. Aim of the present study is to propose a model for electrocardiographic QT-interval estimation from PCG. To this aim, simultaneously acquired 30-second PCGs and ECGs of 99 healthy subjects were processed to obtain median PCG and ECG beats (Figure). Beat length (L; ms), S1 onset (S1on; ms) and S2 onset (S2on; ms) were identified from the median PCG beat, while QT interval (QT; ms) was measured from the median ECG beat. Then, the following regression model was used to obtain a PCG-based QT estimation ($\widehat{QT}$) of electrocardiographic QT:

$$\widehat{QT} = p_1 \cdot S1on + p_2 \cdot S2on + p_3 \cdot L + p_4 \cdot S1on \cdot S2on + p_5.$$

The model was formulated by regression analysis between $\widehat{QT}$ and QT and validated by leave-one-out cross-validation. Correlation coefficients (ρ) and error distributions (ε) for both model formulation and validation were computed. Obtained regression coefficients were p_1=-3.3 (dimensionless), p_2=-0.9 (dimensionless), p_3=0.1 (dimensionless), p_4=5.4 (ms^{-1}) and p_5=825 (ms). $\widehat{QT}$ and QT were significantly correlated and their median ε is 1 ms in both model formulation (ρ=0.7; $p<10^{-13}$;ε=1[-12;15] ms) and validation (ρ=0.6; $p<10^{-10}$; ε=1[-15;16] ms). Thus, the proposed model provides a reliable estimation of the QT interval from phonocardiographic heart sounds in healthy subjects.



L, S1on and S2on identification from median PCG beat (black) and QT measure from median ECG beat (red).