A Spatio-Temporal Study of Ischemia and the Time-Frequency Coupling Variations between the ST Amplitude, Heart Rate and Dominant Angle

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An analysis of the Long Term ST Database (LTSTDB) was conducted to quantify the duration and magnitude of ischemic episode changes across leads and through time. An episode was defined to last as long as any single lead indicated clinically significant ST changes. We calculated that the LTSTDB contains 1135 episodes of ischemia and 360 episodes of non-ischemic rate-related ST changes in 86 recordings from 80 subjects. We calculated that the length of the ischemic episodes closely matched a log-logistic distribution with μ=5.56 and σ=1.01. For the 15 recordings that possess orthogonal (EASI) leads sets we derived the 12 standard leads and analyzed the spatial time course (from the j-point to j+120 ms) of each episode over time to identify dominant trends. Although the magnitude of the ischemic episodes did not reveal any inter-subject trend (except for generally exhibiting Brownian-like motion), there appeared to be strong correlations with the heart rate (HR). Wavelet cross-spectral coupling with significance testing was then applied to the ST-amplitude and HR evolution over the course of each episode. In all subjects significant cross-spectral correlations were found at very low frequencies ($<$0.04 Hz), as well as at respiration and baroreflex frequencies. This indicates that the ischemic episodes are modulated by blood pressure and activity or HR-related phenomena and that all episodes in the LTSTDB are of a 'mixed' type at some point in their duration. The dominant angle of the ischemic episodes was also calculated. Although this angle evolved over time, it generally drifted by only a few degrees even over long episodes. A few large angle changes were observed although no clear explanation for these shifts can be found. The dominant angle also showed significant correlation ($P<0.01$) with the ST amplitude and HR changes at similar frequencies to those described above.