

Relationship between Fractal Dimension and Power-Law Exponent of Heart Rate Variability in Normal and Heart Failure Subjects

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Among the plethora of methods proposed to study the fractal-like behavior of heart rate variability (HRV), the power-law exponent (beta) and the fractal dimension (FD) have gained wide acceptance. Since HRV behaves like self-similar fractional Brownian motion (fBm) process, the linear relationship existing between beta and FD indices for fBm is often used to express one parameter in terms of the other. Objective of the study was to check the reliability of fBm in modeling HRV, focusing on the possible differences between normal (NR) and heart failure (HF) series. To this aim, 50 NR-HRV series and 50 HF-HRV series, extracted from 24-h Holter recordings, were analyzed. FD was estimated with Higuchi's algorithm. Power-law beta exponent was calculated as the slope of the periodogram on a log-log plot within three different common narrow low-frequency bands as well as in the whole HRV frequency range. Both parameters were estimated every hour. Preliminary results showed that a linear relationship can be found only when beta is calculated in the whole HRV frequency range, being the two parameters almost independent in the considered narrow low-frequency bands. The relation is different for NR and HF populations and it differs from the theoretical one ($\beta = 5 - 2D$) valid for fBm series, suggesting no true self-similar behavior. In conclusion, the common practice of estimating beta from FD values for HRV series using the theoretical linear relation, should be reconsidered. A linear relation between the two parameters, though different from the theoretical one, can be found, in fact, only when beta is calculated in the whole HRV band. Moreover, the relationship seems not to be unique for NR and HF subjects. Finally, being the HRV beta exponent potentially less than or equal to 1, the linear relationship saturates to a FD value of 2.