Letters to the Editor

Importance of Appropriate Spectral Methodology to Assess Heart Rate Variability in the Frequency Domain

To the editor:

The article “Short-term variability of blood pressure and heart rate in borderline and mildly hypertensive subjects” by Takalo and coworkers1 deserves a comment in view of some methodological oversights and statements that might engender undue confusion in this rapidly growing field of research.

In their spectral analysis of heart rate and arterial pressure variability, the authors considered three bands of interest, determined a priori and defined as low-, mid-, and high-frequency. This procedure was previously followed by authors who used the fast Fourier transform (FFT) algorithm.2 This is surprising because Takalo et al1 used an autoregressive approach that, by applying a residuals theorem,3 can instead provide automatically the number, center frequency, and associated power of oscillatory components without the need for a priori decisions. Moreover, they used a very high model order (ie, 30), which generates a noisy spectral profile similar to the one obtained with unsmoothed FFT (see middle and bottom part of the Figure). This is quite different from what is obtained when Akaike’s criterion is applied to choose an appropriate model order (ie, 11 in the case of the top part of the Figure).

This point is crucial because it has been amply demonstrated in addition to a very-low-frequency or DC component below 0.03 Hz, only two rhythmical oscillations affect both heart period and arterial pressure variability, with a high degree of coherence. This is so in human subjects, conscious dogs, anesthetized cats, and unanesthetized rats.4 The center frequency of the high-frequency component corresponds to that of respiration, whereas the center frequency of the low-frequency component reflects vasomotor activity; however, the center frequency of this latter component can also vary considerably (in human subjects and conscious dogs from 0.04 to 0.13 Hz). In short, it is clear from previous studies and from the example provided in the Figure that an arbitrary cut at 0.075 Hz can only artificially subdivide into two parts the same rhythmic phenomenon.

Takalo and coworkers1 justify their methodological choice with the following statement in the “Discussion”: “Finally, our viewpoint is that components with a frequency slower than respiration should, as in Parati et al,2 be divided into two bands, where the lower limit of the center frequency in the baroreflex rhythm, that is, 0.075 Hz, is a logical dividing line.” This a priori logic is likely to introduce a major confounding factor. Indeed, the authors could not clearly detect either the differences in day-night changes of spectral components as previously reported or those that exist between normotensive and hypertensive subjects.5-9 Available evidence indicates that a sound spectral methodology, by comparing the relative power of oscillations related respectively to vasomotor and respiratory activity, is providing a new tool for assessing the state of sympathovagal balance in different physiological and pathophysiological conditions, including the sympathetic overactivity of arterial hypertension.5-9

References


Alberto Malliani
Massimo Pagani
Federico Lombardi
Centro Ricerche Cardiovascolari CNR
Medicina Interna II, Ospedale “L. Sacco”
Università degli Studi
Milano, Italy
Response

In response to the letter from A. Malliani et al regarding our study,1 we provide the following comments.

We used the autoregressive (AR) modeling method in our study because it is able to provide better frequency resolution than fast Fourier transformation. However, proper use of the method is required to obtain a high-resolution power spectrum. Crucial to the analysis is the selection of an appropriate model order. Too low a model order results in a highly smoothed spectral estimate with low resolution, and too high an order increases the resolution at the cost of introducing spurious peaks in the spectrum.2,3 Many different criteria have been introduced to guide the selection of the suitable model order, notably the Akaike Information Criteria (AIC).4 Although these criteria are found to work acceptably well in the case of a pure AR process, they have been reported to underestimate the model order in the case of non-AR or noise-corrupted processes,5 as is the case when analyzing blood pressure (BP) and heart rate (HR) signals. In fact, it has been observed that the AR model order chosen by AIC is usually not sufficient to resolve spectral details in noise-corrupted signals.5 Thus, when aiming at the maximization of the spectral resolution, a greater model order than that estimated with AIC should be used. Kay2 stated that as a rule of thumb in the spectral estimation, a model order between N/3 and N/2 (N being the data length) should be used for good spectral resolution and few spurious peaks. The AIC gives estimates between 6 and 22 when used with corrupted processes,2,3 as is the case when analyzing blood pressure and pulse interval in humans. Hyperension. 1990;16:414-421.


References

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