Power spectral analysis of heart rate and blood pressure: markers for autonomic balance or indicators of baroreflex control?

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In this issue of Clinical Science (see pp. 103–109) Sleight et al. raise the question of whether power spectral analysis of heart rate and blood pressure offers useful markers for sympathetic and parasympathetic tone, or whether they are largely an index of baroreflex gain. When power spectral analysis of cardiovascular parameters was introduced to haemodynamic investigations [1], broad enthusiasm for this method developed. It was considered a promising tool to assess autonomic nerve activity by non-invasive techniques. This is of particular clinical interest, since diagnosis, therapy and prognosis of many cardiovascular diseases may rely on the sympato-vagal balance [2]. Based on experimental and clinical studies employing pharmacological receptor blockades [3], various stressors [4] or several pathophysiological states [5], the general concept was that low-frequency oscillations (0.1 Hz in humans) reflect sympathetic (and perhaps also parasympathetic) nerve activity, whereas respiration-related, high-frequency oscillations (0.25 Hz in humans) mirror parasympathetic tone [6, 7]. However, serious concern about this concept was raised by DeBoer et al. [8]. They introduced a beat-to-beat model of the cardiovascular system that could explain low-frequency oscillations in heart rate and blood pressure as a resonance phenomenon due to the delay in the sympathetic control loop of the baroreflex. This point of view is supported by a number of studies in sinoaortic denervated animals [9, 10].

In their paper, Sleight et al. attempted to test the DeBoer model. Briefly, they applied power spectral analysis to one normal subject and two patients with heart failure during controlled respiration combined with rhythmic baroreceptor stimulation by sinusoidal neck suction. The interesting feature was that the three subjects differed not only in sympathetic tone, but also in baroreflex sensitivity. Furthermore, one of the patients with heart failure initially had a poor baroreflex, but improved considerably over a time period of 6 months, thus allowing an intra-individual comparison. Although it can be assumed that sympathetic tone was higher in the two patients with heart failure, low-frequency power during basal conditions was not higher in the two patients compared to the control subject. Transition of 0.1 Hz and 0.2 Hz oscillations to the baroreceptors by sinusoidal neck suction induced corresponding peaks in the spectra of the normal subject and in the patient with good baroreflexes, but not in the patient with poor baroreflexes. Improvement of the baroreflex sensitivity in the latter led to a more pronounced transition of the baroreceptor-induced heart rate oscillations. Based on these findings, the authors concluded that power spectral analysis of circulatory variables may indicate baroreflex sensitivity rather than sympathetic or parasympathetic tone.

Although the experimental design is promising, there are some methodological problems in this study. First, only three subjects were included in the study, one young normal individual and two older patients. Based on this small database, the authors cannot provide a statistical analysis of their results. Also, the different ages of the control subject and the two patients are problematical since it has been shown that power spectra of blood pressure and heart rate can change with age [6, 7]. Finally, absolute spectral powers are given. Some authors, however, prefer relative powers or the relation of low- to high-frequency power as more reliable markers for autonomic nerve activity [6].

Despite these methodological limitations of the study by Sleight et al., the authors stress a very important point: it may be too simplistic to use power spectral analysis as a simple measure for autonomic balance because its underlying modulation is more complex than generally believed. In the past, numerous papers [11, 12] have been published in which power spectral analysis was used as a tool to evaluate autonomic tone. In the light of the
actual discussion about the meaning of the markers obtained by power spectral analysis, it does not seem feasible to use them as the only markers for the activity of the autonomic nervous system. Until the nature of blood pressure and heart rate oscillations become clearer, more traditional markers, such as noradrenaline release or direct nerve recordings must be combined with spectral techniques in order to draw valid conclusions. This seems to be very important, since spectral markers have been shown to disagree with autonomic tone in various conditions such as exercise [13] or heart failure [14]. In addition, our group was able to demonstrate that chronically elevated sympathetic activity, as seen in the spontaneously hypertensive rat strain, is not accompanied by increased low-frequency variability [15, 16].

In conclusion, based on the current literature, the interpretation of data obtained by power spectral analysis should be treated with caution. The biological correlate is still a matter of debate. At present, there is increasing evidence for the concept that power spectral analysis reflects the sensitivity of cardiovascular control systems, such as the baroreceptor reflex, rather than autonomic tone. Whether power spectral analysis of heart rate or blood pressure will become a reliable clinical tool in the diagnosis of cardiovascular diseases remains to be elucidated.

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REFERENCES


