EDITORIAL COMMENT

Origin and Significance of Heart Rate Variability*

Mikko Tulppo, PhD,†
Heikki V. Huikuri, MD, FACC‡
Oulu, Finland

Measurement of heart rate variability (HRV) has become an important research tool for both clinical and basic scientists (1,2). The better reproducibility and the possibility of measuring long-range heart rate (HR) fluctuations are advantages of 24-h electrocardiographic (ECG) recordings over short-term recordings in the assessment of HRV (2). Long-range oscillations of HR determine a larger proportion of 24-h HRV than do short-term oscillations. This phenomenon can be demonstrated by plotting the (log) frequency of R-R interval oscillations (2). Similar characteristics can also be observed at higher frequencies, except that small peaks in the spectrum exist at the frequency of spontaneous blood pressure oscillations and respiratory frequency (2).

Origin of long-range HRV. Despite the documented prognostic information obtained by measurements of long-range HRV indexes from 24-h ECG recordings in various patient populations (3–5), the origin of these oscillations and the background of altered long-term HR dynamics are not well established. Lack of this information may be one of the many reasons why the measurement of 24-h HRV has not become a routine tool in clinical practice. From a mathematical viewpoint, long-range HRV, such as standard deviation of the 5-min mean R-R interval (SDANN) and ULF power, can be assumed to be larger when there are large temporal differences in the mean HR between time epochs more than 5 min apart from each other. Another factor that influences the magnitude of these HRV indexes is the average HR itself. The higher the average HR, the lower the HRV, even when the relative fluctuations of HR are similar at high and low HR, respectively. Despite these mathematical assumptions, the reasons for reduced long-range HRV during “free-running” ambulatory conditions have not been systematically studied.

In this issue of the Journal, Roach et al. (6) report their results on the effects of changes in the daily activity levels on long-range HRV indexes such as SDANN and the ULF power spectral component (6). In their study, where activity was strictly controlled, SDANN and ULF power were lower during the “rest day” than the “activity day.” Furthermore, the relative contribution of each specific activity to the SDANN value was calculated. On the basis of their observations, the authors conclude that long-range HRV indexes are partly dependent on the range of daily activity (6).

Although changes in activity level have evident influences on various indexes of HRV, some caution should be observed in assuming that long-range HRV indexes could simply be used as “surrogates” of individual daily activity and functional state. Although SDANN and ULF power are influenced by the amount and duration of various daily activities, the type of physical activity may have divergent effects on measures of HRV. This is illustrated in Figure 1, where steady-state exercise (i.e., walking at a constant rate and regular activities in the standing position) resulted in a reduction of SDANN, whereas an incremental exercise with a long-term trend in HR resulted in an increase of SDANN. These examples from a previous study (7) demonstrate that there is complex interaction between the type and duration of physical activity, average HR, and the indexes of long-range HRV.

On the basis of the study by Roach et al. (6) and the observations shown in Figure 1, it is evident that range, duration, and type of activity have obvious effects on various measures of HRV. However, these experiments do not give insight into whether the ULF oscillations of heart period are also determined by periodic or quasiperiodic oscillations of HR originating from an intrinsic regulatory system. Further studies will be needed to address this issue. The postulation of an intrinsic physiologic origin is supported by the notion of a dominant ULF power spectral component, even during strictly controlled resting conditions without any physical activity.

HRV in chronic heart failure (HF). Several studies have reported reduced long-range HRV among patients with chronic HF to be associated with increased mortality (5,8–11). However, conclusive understanding of the pathophysiology of the reported alterations in HRV in HF is still lacking. On the basis of the results by Roach et al. (6), it is possible that the reduced long-range HRV in patients with chronic HF is partly due to the reduced range of physical daily activity and the higher HR of the patients without beta-blocking medication. However, it is evident that reduced HRV in HF is also a result of altered cardiac autonomic regulation. This is supported by a large body of evidence documenting autonomic dysfunction consisting of sympathetic activation, parasympathetic withdrawal, and unresponsiveness of peripheral organs in HF (12–15).

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†Division of Cardiology, Department of Medicine, University of Oulu, Oulu, Finland. Supported in part by the Medical Council of the Academy of Finland, Helsinki, Finland; and the ‡Merikoski Rehabilitation and Research Center, Oulu, Finland.
short-term HR dynamics, seems to have prognostic significance among post-infarction patients (23). Taken together, these recent observations suggest that analysis of short-term HR dynamics may better reflect the abnormalities in intrinsic autonomic regulatory systems and the risk of mortality than do long-range HRV indexes.

It can be concluded that we still have insufficient understanding of the exact underlying mechanisms that induce the observed alterations in HRV in chronic HF. Despite the active research on the various aspects of HRV, new research models and large prospective evaluations will still be needed before widespread application of this technique becomes possible.

Reprint requests and correspondence: Prof. Heikki V. Huikuri, Division of Cardiology, Department of Medicine, University of Oulu, P.O. Box 5000 (Kajaanintie 50), FIN-90014 Oulu, Finland. E-mail: heikki.huikuri@oulu.fi.

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