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Heart Rate Variability Today

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Abstract Heart rate variability (HRV) non-invasively assesses the activity of the autonomic nervous system. During the past 30 years, an increasing number of studies have related the imbalance of the autonomic nervous system (as assessed by HRV) to several pathophysiogical conditions, particularly in the setting of cardiovascular disease. Sudden death, coronary artery disease, heart failure, or merely cardiovascular risk factors (smoking, diabetes, hyperlipidemia, and hypertension) are the best-known clinical circumstances that can affect and/or be affected by the autonomic nervous system. Analyses of HRV variables have been proposed as a component of the clinical evaluation for patient risk stratification due to its independent prognostic information. Yet the potential for HRV to be used widely in clinical practice remains to be established. (Prog Cardiovasc Dis 2012;55:321-331)
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"A balance that does not tremble cannot weigh, A man who does not oscillate is a dead one" Erwin Chargaff

The autonomic nervous system regulates visceral functions through the sympathetic and parasympathetic branches which act antagonistically to preserve a dynamic equilibrium of vital functions. In the cardiovascular system this nonstationary balance results in the fluctuation between intervals of consecutive heart beats, so called heart rate variability (HRV).

Impaired autonomic activity has been shown to be an independent predictor of mortality after myocardial infarction.[1–6] A wide spectrum of other pathophysiological conditions are influenced by an imbalance in autonomic activity, including atherosclerothic plaque progression, congestive heart failure, diabetic neuropathy, susceptibility to sudden death in infancy and psychiatric disorders such as depression.

HRV has emerged as the most valuable non invasive test to assess autonomic nervous system function. The aim of our work is to give readers a first approach in understanding how HRV observation may be helpful in explaining autonomic variations in common physiological and pathologic conditions, with greater focus on cardiovascular manifestations.

Analysis of HRV

In 1996, a task force composed of members of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology created the necessary guidelines for comparing different assessment models of HRV. HRV measures were divided into two broad categories: time domain and frequency domain measures.[7] The rule of thumb is that data obtained from short-term (5 minutes) recordings should be processed with frequency-domain methods, whereas time-domain analyses should be performed to analyze

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Abbreviations and Acronyms

CRT = cardiac resynchronization therapy

HF = high frequency

HRV = heart rate variability

LF = low frequency

PNN50 = ratio between NN50 and the total number of NN intervals

RMSSD = root mean square of successive R-R interval differences

SDANN = standard deviation of the average normal R-R intervals

SDNN = standard deviation of normal R-R intervals

ULF = ultra low frequency

VLF = very low frequency

24 hour, long-term, recordings. Both time window recordings have some limitations. Short-term recordings may fail to detect very low frequency oscillations, while data from long-term recordings are more prone to be influenced by external alternating environmental conditions. It is therefore important to normalize environmental situations when examining HRV data. Furthermore, as the HRV reflects the activity of the autonomic nervous system on the sinus node, abnormal heart beats and artefacts should be excluded from electrocardiographic (ECG) recordings to achieve more reliable results.

Time-domain methods

Time domain methods in a continuous ECG recording permit determination of either instant heart rate or intervals between successive normal QRS complexes (normal-to-normal R-R interval, NN) and other variables derived from NN intervals, for instance, mean NN interval, the mean heart rate, the difference between the longest and shortest NN interval, and the difference between night and day heart rate (Table 1).

More clinically useful parameters of HRV, assessed with statistical operations on R-R intervals, are a measure of the dispersion of individual cardiac cycle length around their mean, including standard deviation of normal R-R intervals (SDNN), the standard deviation of the average normal R-R intervals (SDANN), the root mean square of successive R-R interval differences (RMSSD) and the percentage of normal R-R intervals that differ by 50 ms (pNN50). All the HRV indices with the exception of pNN50 are reported in units of time (ms).

SDNN is a marker of the total power (variance) of HRV and reflects all long-term components responsible for variability in the recording period, including circadian rhythm and physical activity. It is typically measured over 24 hours by Holter monitor. Since the total variance of HRV is directly related to the length of analyzed recording[8] it is misleading to compare SDNN measures obtained from ECG strips of different durations. The role of SDNN in predicting mortality after acute myocardial infarction was first demonstrated by Kleiger et al.[2] in 1987 and later corroborated by several studies including Autonomic Tone and Reflexes After Myocardial Infarction (ATRAMI) and Gruppo Italiano per lo Studio della Sopravvivenza nell' Infarto Miocardico 2 (GISSI-2).[9,10]

HRV analysis in ECG recordings shorter or longer than 24 hours may be estimated by dividing the long-term ECG Holter monitor into 5-minute segments and may be performed in order to calculate either the mean of all the 5-minute standard deviations of NN intervals or the standard deviation of the average NN intervals. The former index measures the variability due to cycles shorter than 5 minutes and the latter estimate the variability due to cycles of 5 minutes or longer providing highly sensitive information on the low frequencies such as physical activity, changes in position, or circadian rhythm[11–15]. The number of successive NN length differences larger than 50 ms, either expressed in percentage as the ratio between NN length differences larger than 50 ms and the total number of NN intervals, or the square root of the mean squared differences of consecutive NN intervals are all measurements of short-term variation in the NN cycles and detect high frequency oscillations caused by parasympathetic activity.

Geometrical time-domain methods are obtained through the conversion of the NN interval data into geometrical forms like histograms or the HRV triangular

Table 1
Selected time domain measures of HRV (adapted from ESC/NASPE guidelines).[7]

Variable	Units	Description	Consensus for abnormal value
SDNN	ms	Standard deviation of all NN intervals	↑
SDANN	ms	Standard deviation of the averages of NN intervals in all 5-minute segments of the entire recording	↑
RMSSD	ms	The square root of the mean of the sum of the squares of differences between adjacent NN intervals	↓
SDNN index	ms	Mean of the standard deviations of all NN intervals for all 5-minute segments of the entire recording	↑
SDSD	ms	Standard deviation of differences between adjacent NN intervals	↓
NN50	count	Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording; three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer	↓
pNN50	%	NN50 count divided by the total number of all NN intervals	↓

↑ = increased sympathetic activity; ↓ = decreased vagal activity.

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