

The Origin of Disease and Health, Heart Waves: The Single Solution to Heart Rate Variability and Ischemic Preconditioning

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In the world of medicine are two extraordinary experimental mysteries that intuition at first suggests are totally unrelated. The first mystery, from the field of cardiology, is: Why does a decrease in heart rate variability (HRV) emerge as a single common risk factor for virtually all chronic disease patients at all ages? The second puzzle, from the field of cardiovascular surgery, is: Why should the process of cyclically clamping and de-clamping the coronary arteries—called ischemic preconditioning—just prior to clamping them for a prolonged period during coronary surgery protect the myocardium from cellular death?

The first mystery is associated with disease and death; the second with survival and life. These associations may be counterintuitive: a decrease in HRV should imply stability and life, not mortality; ischemic preconditioning should imply instability and death, not well being. Moreover, these mysteries are interrelated. Although researchers in molecular biology are looking for two different answers for these mysteries, I am suggesting one, albeit counterintuitive, answer.

As a vascular surgeon dealing with patients in crisis, and as founding chairman of the United States Olympic Sports Medicine Council

dealing with athletes in their prime, I had the unique opportunity to view the heart in both the worst case circumstances in the operating room and in the best case on the playing field. From these combined perspectives, I have developed a new understanding of heart behavior called heart waves, which also suggests the way waves behave in nature.

This new understanding of wave behavior explains how the seemingly complex, disparate information of the body's behaviors, molecular biology, and genes is organized into a single coherent picture. I call this the wave theory.¹

The theory has wide implications. It not only suggests an explanation for the two mysteries but also explains the underlying origin of chronic disease; at the same time, it provides the means for prevention and reversal of those diseases and the means for optimizing health, performance, and longevity. This paper presents the wave theory, previously described in the context of universal law,² as it relates to the function of the human heart in biology and medicine.

Why is Decreased Heart Rate Variability (HRV) Associated With So Many Health and Behavior Disorders?

HRV is a simple measure of the beat-to-beat evenness of consecutive heartbeats. A decrease in HRV corresponds to consistent interbeat intervals (IBI). The more metronome-like the heart rate, the lower the HRV. Conversely, the more uneven the IBI, the greater the HRV.

HRV is easily calculated by measuring the time between successive R-R intervals of QRS complexes as recorded on an electrocardiographic strip (Figure 1a, b). To measure HRV and heart rates over linear time, each heart-beat cycle of systole and diastole is treated as a dimensionless point. Medicine ignores nature's cycles of systole and diastole in favor of idealizing the cycles as serial points in a straight line to calculate beat-to-beat heart rate variability. The patterns of natural heart beats are converted into points, lines, and numbers (as if there were gaps from point to point). In this dematerialization of the cyclic heart pattern into abstractions the natural continuum of the heart wave is lost (see Figure 1c, d).

Over the last thirty years a decrease in HRV has received increasing attention as a prognostic indicator of risk associated with a variety of

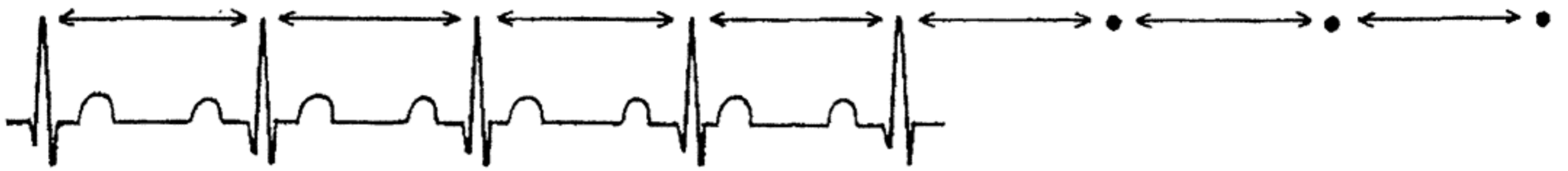


Figure 1a. Decreased HRV on an ECG.

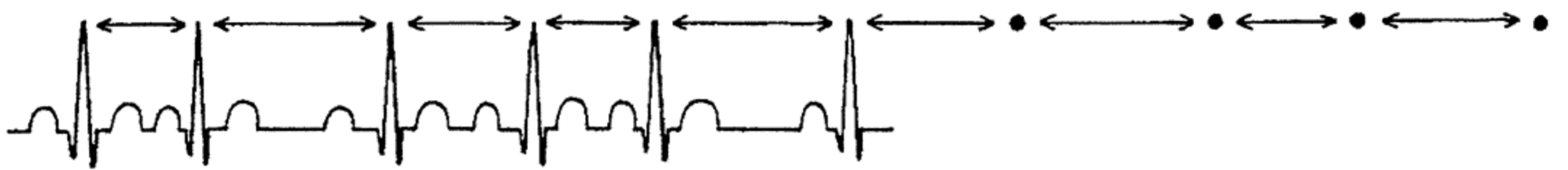


Figure 1b. Increased HRV on an ECG.



Figure 1c. Decreased variability of systole/diastole.



Figure 1d. Increased variability of systole/diastole.

chronic diseases, behavioral disorders, mortality, and even aging. The finding of one single risk factor for such a wide variety of problems is unexpected. Historically medicine has searched for a single causal agent—such as a molecular abnormality, a virus, or a genetic mutation—as the etiology of any particular disease. Similarly we tend to think of a specific risk factor as being associated with a particular disease. Consequently the discovery of a single risk factor associated with the widest spec-

trum of disorders is strong evidence of some underlying connecting phenomenon of disease and health that we have not yet understood.

Decreased HRV in Health and Behavioral Disorders

A review of the literature shows the magnitude of decreased HRV as one single risk factor involving a surprisingly wide spectrum of disorders—from *in utero* and infant mortality to geriatric mortality; from cancer and cardiovascular disease to au-

toimmune and behavioral disorders; from HIV/AIDS infection to drug addiction and juvenile delinquency. No other single risk factor has been implicated so convincingly and in such a wide range of conditions.

The first description of a decrease in HRV as a risk factor for disease was published in 1965 by E. H. Hon and S. T. Lee when they observed its association with infant mortality.³ Schechtman, et al., found decreased HRV in Sudden Infant Death Syndrome.⁴ Intriguingly a more recent

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study on SIDS by Harper reported a low variability in the intervals between breaths in SIDS babies.⁵ As part of the Framingham Heart Study, H. Tsuji, et al., reported that in an elderly cohort with a mean age of 72 ± 6 years reduced HRV was found to predict mortality from all causes, in particular cancer and cardiovascular disease.⁶ They concluded that ambulatory ECG monitoring of HRV offers prognostic information that can supplement that provided by the evaluation of traditional risk factors. Clearly, this has important implications for all of medicine and science.

A current Framingham Heart Study describes the impact of reduced HRV on risk for cardiac events.⁷ This was the first prospective study to suggest an association between reduced HRV and heart disease risk in a community-based population. Hayano, et al., reported a positive correlation between decreasing HRV and the progression of coronary artery disease.⁸ Temoshok, et al., showed that patients with HIV infection and AIDS who displayed increased heart rate reactivity and "physiological toughness" survived significantly longer than those with decreased HRV.⁹ Neubauer, et al., found in patients with multiple sclerosis reduced long term and short term HRV marked by "an abnormally great regularity, broken now and then by peculiar bursts of changes in heart rate."¹⁰ In another autoimmune disease study, Murry, et al., correlated decreased HRV with insulin dependence in diabetic males.¹¹ Gunderson, et al., saw a similar HRV pattern in juvenile diabetics.¹²

Hirsh, et al., found that HRV decreased in subjects with weight maintenance at higher than "usual" levels but increased with low-calorie feeding or with weight maintenance at lower than "usual" levels.¹³ Garfinkel, et al., found reduced HRV among cocaine users.¹⁴ Raine, et al., found correlations between HRV and juvenile delinquency and adult criminal behavior.¹⁵ The significance of the finding of decreased autonomic arousal associated with a low heart rate has been confirmed through additional research by Adrian Raine in Mauritius. He studied 1,795 children between the ages of 3 and 11 and found a statistically significant correlation between the incidence of aggression and those turning to juvenile crime with a decrease in autonomic arousal and heart rate.¹⁶ Lowensohn found low HRV among patients with severe brain damage.¹⁷

In 1994, an International Task Force representing the European Society of Cardiology and the North American Society for Pacing and Electrophysiology was established to study HRV. The task force identified changes in HRV that may be early manifestations of neurological disorders including Parkinson's disease, multiple sclerosis, and Guillain-Barre syndrome. The Task Force also suggested that HRV may contribute to our understanding of the effects of space flight.¹⁸ Goldberger, et al., saw evidence that bed-rest reduces HRV.¹⁹ Waddington, et al., showed that HRV declines linearly with age.²⁰ O'Brien, et al., found a similar decline of HRV

using a computerized method of measurement of R-R interval variation.²¹

Though aging is not a chronic disease per se, a decrease in HRV associated with aging is significant for two reasons: (1) the general incidence of chronic disease increases with increasing age and (2) both a decreased maximum heart rate and a decrease in HRV are found to be associated with increasing age.

The HRV International Task Force

The above studies all point to the fact that HRV stands alone as a single risk factor of virtually all chronic diseases and behavioral disorders at all ages. However, despite HRV being easy to quantify, without a definitive understanding of what HRV truly represents, it has remained a complex issue for medical science. This was emphasized by the HRV International Task Force of mathematicians, engineers, physiologists, and physicians.

The Task Force's objective was to study the many ramifications of HRV including the significance and meaning of its many different measures.

The goals of the Task Force are: to standardize the nomenclature and specify standard methods of measurement, to define physiological and pathophysiological correlates, to describe appropriate clinical applications, and to identify future areas of research.²²

HRV, Maximum Heart Rate, and Heart Waves

The solution to the HRV mystery requires a new understanding of how

