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chapter 96 – Enhancing Heart Rate Variability

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Heart rate variability, the beat-to-beat fluctuation in the rhythm of the heart, is a promising new marker of health, indicating a person's risk for cardiovascular disease and possibly underlying a number of other diseases involving the autonomic nervous system. The data are impressive for the role of heart rate variability (HRV) in predicting heart-related morbidity and mortality.[1] [2] [3] [4] [5] Likewise a growing body of literature demonstrates a relationship between HRV and other diseases involving sympathovagal balance, such as diabetic neuropathy,[6] and even psychological disorders, such as depression.[7] [8] [9] [10]

Given the potentially vast influence of HRV, it becomes important for clinicians and patients to know what they can do to improve this aspect of health. The aim of this chapter is to provide a brief review of the physiology underlying HRV, followed by a review of the current literature on the associations between HRV and health status. Finally, options for preventive maintenance and improving HRV are discussed.

Overview

Heart rate variability is driven by an ongoing interplay between the sympathetic and parasympathetic nervous systems, which together form the two branches of the autonomic nervous system (ANS). The ANS responds to triggers from outside and inside the body, including environmental stimuli such as heat and pressure, stressors like fatigue and fear, positive emotional states such as appreciation, and internal cues from the immune system, endocrine system, and the cardiorespiratory system among others.

New research from neurocardiologists and from the HeartMath Institute indicate that the heart is a much more complex player in nervous system pathways than previously appreciated. Not simply a pump, the heart is also a sensory organ, playing a critical role in information encoding and processing. The circuitry of the heart actually allows it to learn, remember, and make functional decisions independent of the cranial brain. In fact, researchers at the HeartMath Institute have come to call the heart a “heartbrain,” due to its extensive, intrinsic nervous system.[10] The signals coming from the heart to the brain affect not only the ANS, but travel also to higher centers in the brain responsible for perception and emotion.[11] These findings have fueled the now burgeoning fields of neurocardiology and psychoneuroimmunology or neuroendocrinology, all of which have developed a systems model outlining the way bodily systems inform and respond to each other, mutually contributing to our learning styles, coping skills, intelligence, emotional state, and ultimately to our overall health and longevity.

Physiology and Measurement of HRV

As stated above, HRV is directly driven by the sympathetic and parasympathetic nervous systems, which are in constant interplay in an attempt to keep the body in a state of balance, or homeostatis. This balance is dynamic, however—not static. The healthy body undergoes constant adjustments, small and large, to respond appropriately to internal and external cues. Under conditions of rest, the healthy heart is under the control of the vagus nerve, and hence under parasympathetic dominance. Vagal predominance exists during most of the sleep cycle, during digestion, and during times of quiet, focused attention, such as during meditation or prayer. The arousal/erection stages of love-making, too, are driven by the parasympathetic system.

When conditions change and any sort of stressor is introduced, such as dealing with an injury, acute illness, or physical pain, or experiencing fear or anger, the sympathetic system takes over. This sympathetic burst is necessary in the short run as the body may need to increase heart rate and cardiac output (to outrun a real or perceived threat) or to increase catacholamines like adrenaline for strength and vigilance.

In the healthy person, these two systems are called into play appropriately and likewise, are turned off when not needed. However, under chronic stress, in which a short-term stressor becomes long-term, the body tries to compensate by turning up parasympathetic control. The two systems may compete inappropriately, causing erratic or unhealthy patterns in the heart rate and its overall variability.

Whenever the sympathetic system becomes hyperactive, the heart's electrical system can become unstable, causing arrhythmias, platelet aggregation, coronary artery constriction, and increased stress on the left ventricular wall and unhealthy remodeling. Reestablishing proper vagal input antagonizes these sympathetic over-responses and rebalances the system. This happens in part through cardiac baroreceptors which are sensitive to pressure changes, and thus can act centrally to restore proper vagal tone and reduce blood pressure. Baroreceptor sensitivity (BRS) is a marker of the body's capacity to reflexively augment vagal tone.

Baroreceptor sensitivity has a direct link to HRV, observed in respiratory sinus arrhythmia (RSA), the natural irregularity in the heartbeat that reflects the body's response to intrathoracic pressure. When we breathe in, intrathoracic pressure goes down, and in compensation, the heart rate goes up. When we breathe out, intrathoracic pressure goes up, and the heart rate drops. In general, when we breathe faster, sympathetic tone increases, and heart rate also climbs. When we breathe more slowly, balance shifts toward the parasympathetic system, and heart rate slows, overall.

Thus, under conditions of ideal health, the heart does not beat at a steady rate, but rather it varies, both in coordination with the breath, and in response to triggers in the environment.

In medicine, the most well-known example of this phenomenon is seen in obstetrics, where it is common practice to follow the heart rate of the fetus, assessing for adequate variability, that is, an adequate number and duration of accelerations of the baby's heart beat above the baseline heart rate. Variability is interpreted as a sign that the baby is responding well to the environment of the uterus and to the challenges of labor (Fig. 96-1).

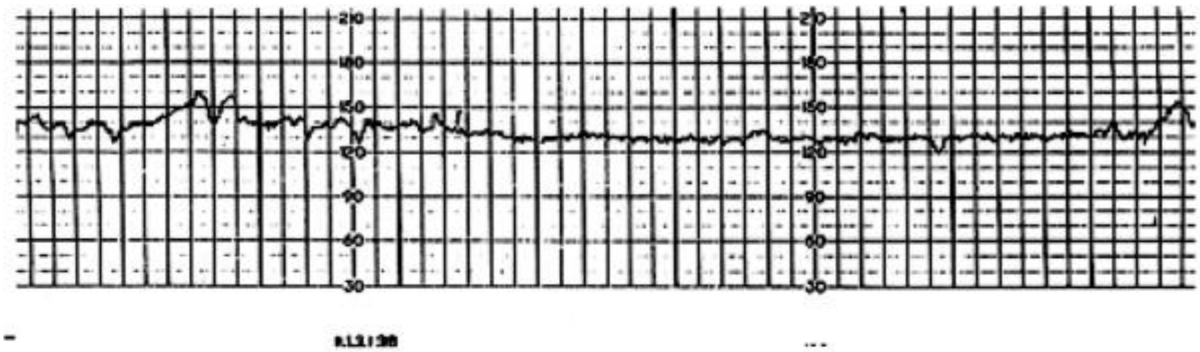

FIGURE 96-1 Fetal heart tones. This fetal heart tone strip shows that the baby's heart regularly rises significantly above the baseline of 130 beats/min.

Likewise, current evidence indicates that adults need a flexible, dynamic, and well-balanced ANS in order to respond appropriately to times of stress and also to the need for rest and regeneration. In a state of health or positive emotion, the parasympathetic and sympathetic systems will produce a low to moderate output, oscillating in relative regularity, producing what is known as a “coherent” HRV pattern, with a largely smooth, sinewave-like curve. In such a state, although the sympathetic system and parasympathetic system are well synchronized, there is an overall shift toward parasympathetic dominance. In contrast, in a state of anger, for example, or in states of chronic illness, the HRV curve is erratic and shallow, reflecting the discordant functioning between the two branches of the ANS and a relative shift toward sympathetic drive.[11]

Below are some graphic examples of HRV. The tachogram in Figure 96-2 , from the HeartMath Institute, demonstrates the use of a biofeedback technique called FreezeFrame to shift from the erratic HRV curve of frustration to appreciation, with a smooth, regularly oscillating curve. Although both emotional states include instances of high heart rate and low heart rate (i.e. they demonstrate a similar peak-to-nadir difference in heart rate), the curves themselves are quite different. Along any given segment of the frustration tachogram, the curve is erratic and shallow, reflecting a low HRV. In contrast, the appreciation curve demonstrates a large peak-to-nadir difference throughout, reflecting the higher HRV. The smooth nature of the curve reflects the coherence of the ANS function under appreciation.[11]

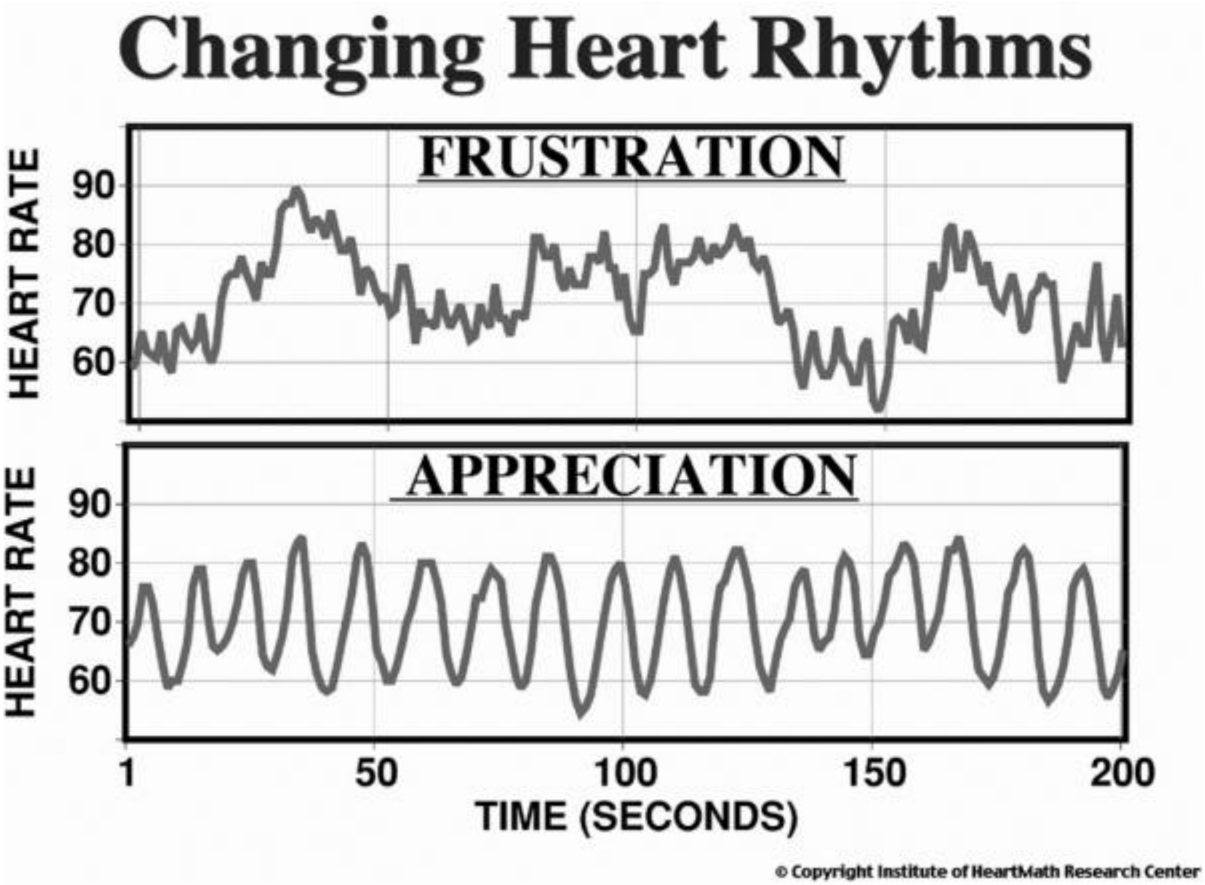

FIGURE 96-2 Frustration to appreciation. Here a person's heart rate variability (HRV) goes from erratic and shallow during frustration to smooth with a more regularly oscillating HRV curve during appreciation. *(From McCraty R, Childre D: The Appreciative Heart: The Psychophysiology of Positive Emotions and Optimal Functioning. Boulder Creek, Calif, Institute of HeartMath. Copyright 2000, Institute of HeartMath.)*

In Figure 96-3 , three states are compared: anger, relaxation, and appreciation. Once again, the tachograms are displayed, along with power spectra analyses, derived from the tachogram patterns. Short term power spectra analyses produce peaks or clusters of data points mostly within three main regions:

1. High Frequency (HF) from 0.15 Hz to 0.40 Hz reflects the activity of the parasympathetic system and the vagus nerve.
2. Low Frequency (LF) from 0.04 Hz to 0.15 Hz reflects sympathetic activity.
3. Very Low Frequency (VLF) from 0.003 Hz to 0.04 Hz reflects a host of factors, including not only the sympathetic nervous system, but also input from chemoreceptors, thermoreceptors, the renin-angiotensin system and others.

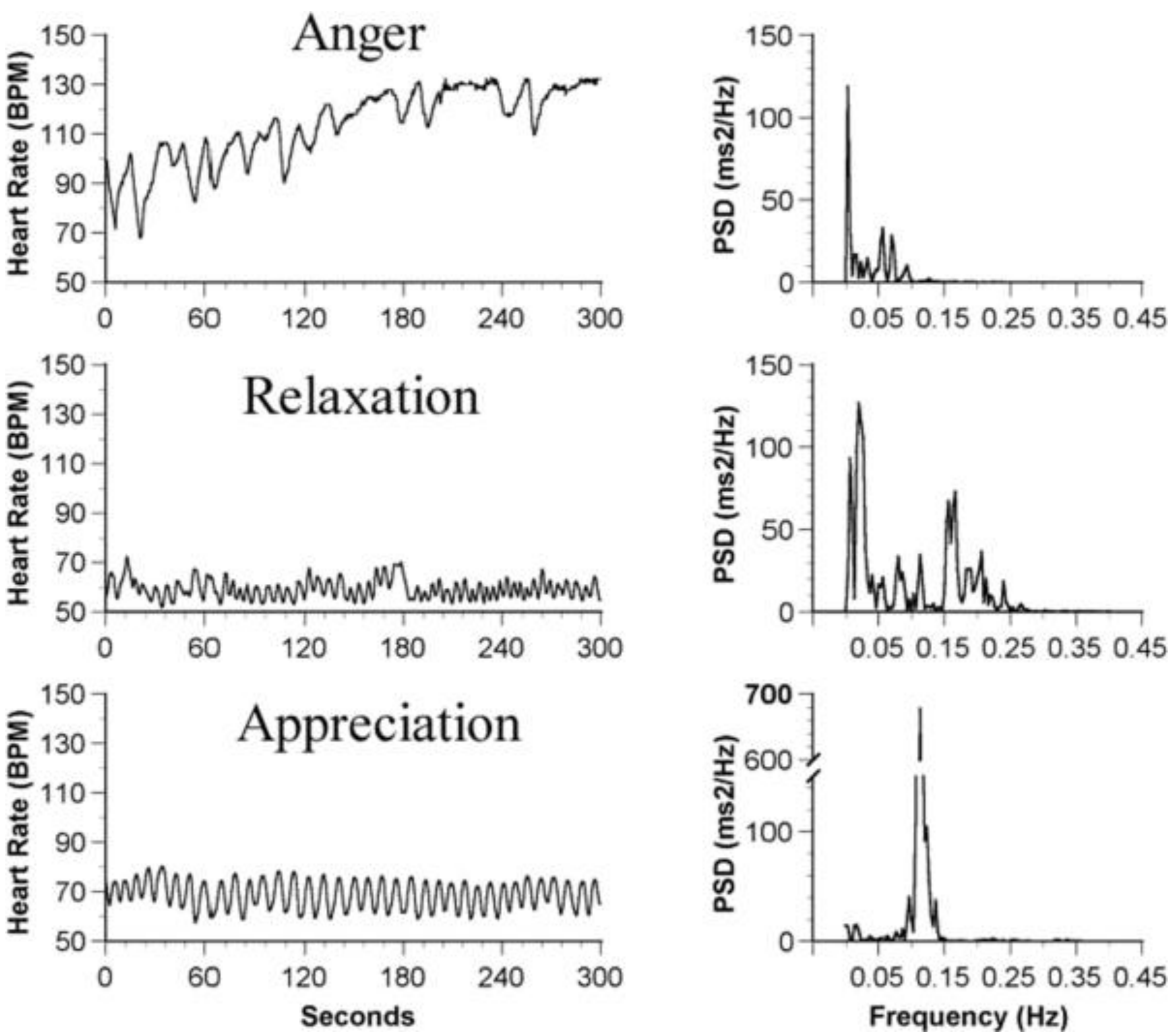

FIGURE 96-3 Anger, relaxation, and appreciation. In these three conditions, note the shift from the erratic heart rate variability (HRV) curve of anger to the somewhat more regular, but low-amplitude curve of relaxation, and finally into the smooth, sine-wave–like curve of appreciation, consistent with "coherence" or good synchronization between sympathetic and parasympathetic systems and the rest of the bodywide network of inputs. *(From McCraty R, Childre D: The Appreciative Heart: The Psychophysiology of Positive Emotions and Optimal Functioning. Boulder Creek, Calif, Institute of HeartMath. Copyright 2000, Institute of HeartMath.)*

The Ultra-Low Frequency region (ULF) becomes important when long-term measurements, such as 24-hour Holter monitor readings, are taken. Although a clear interpretation of the ULF region has not yet been made, approximately 90% of the variability of the heart rate will be found in these two, lowest-frequency regions, VLF and ULF.[12]

In the tachograms,[11] the anger curve demonstrates a disordered pattern, but with an overall increasing heart rate. In relaxation, the tachogram shows a high-frequency, lower amplitude pattern reflecting an overall decrease in ANS outflow. The spike in the high frequency spectrum in relaxation correlates with the shift into parasympathetic dominance. Finally, under the positive emotion of appreciation, a smooth, or highly ordered (or coherent) sine wave is seen. According to the researchers, the large, narrow spike in the low-frequency band is indicative of synchronization between the sympathetic branch and parasympathetic branch of the ANS, as well as an entrainment between heart rate, respiration, and blood pressure. Although appreciation is also high in parasympathetic input, it is different from relaxation because of the oscillation which denotes the synchronization between ANS branches and between the heart and the nervous system. Finally, this coherent mode may or may not involve a lowering of heart rate or even an increase in HRV, per se. (Note that the peak-to-nadir difference in relaxation and appreciation are nearly equal.) Rather, it is the highly organized oscillation, reflecting high levels of synchronization, which sets positive emotion apart from mere relaxation.

Advanced and Exploratory Concepts in HRV

A fascinating branch of research within neurocardiology, with significant contributions historically by researchers and clinicians Irving Dardik, Dan Winter, and Ary Goldberger,[13] indicates that our understanding of the term "coherence," as used to describe a healthy pattern of HRV, may need to be adjusted and expanded. In clinical work, it is known that certain fixed patterns on an EKG are ominous signs. For example, the pattern of slow, periodic oscillation of the heart rate, seen in Cheyne-Stokes breathing in a person with congestive heart failure, is a sign of impending death (Fig. 96-4).

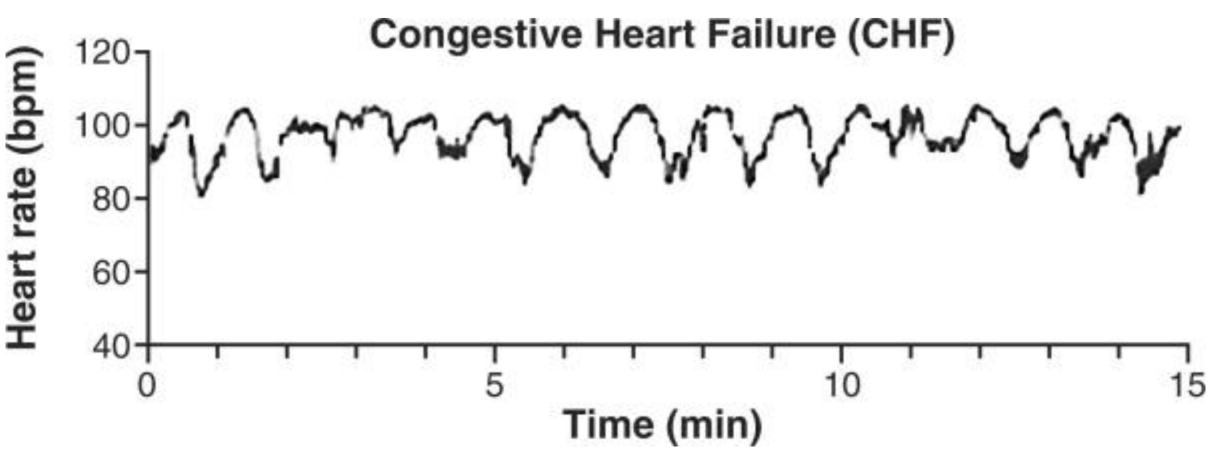

FIGURE 96-4 Cheyne-Stokes breathing in congestive heart failure (CHF). Here, the heart rate is regular, but dangerously so. Apparently some ability to oscillate and respond to bodily cues has been lost in this end stage of CHF.

The above researchers have argued that the heart rate patterns of a healthy human under normal conditions (not necessarily under stress) are actually erratic, or chaotic in appearance. This chaotic appearance is reflective of a healthy response to an ever-changing environment, internal and external. When analyzed with sophisticated computer programs looking for mathematical and geometric patterns, however, subtle patterns emerge from the chaotic-appearing data. They liken these patterns to looking at shapes found within nature, whether a snowflake, a jagged mountain range or coastline, tree branches or even the branching pattern of the bronchial tubes out to the alveoli in human lungs. Although the individual patterns are not perfectly matching, there is a clearly repeated shape within the system, often smaller, repeated versions of a larger shape, such as the tree trunk sprouting ever smaller branches from the core to the periphery. Thus, there is an underlying "coherence," if you will, a subtle but persistent pattern associated with healthy organisms.

Dr. Irving Dardik developed the concepts of nested or embedded waves and harmonic inclusiveness to describe a phenomenon whereby life rhythms (circadian rhythm, heart beat, respiratory cycles, biochemical cycles, for example) can be described using a set of nested waves, embedded one on top of another.[14] In states of optimum health, he has asserted, all of these waves co-exist in a constructive pattern, i.e., without destructive interference. Their synergy contributes to the overall health and energy of that person. The person's heart rate, as well as the other variables mapped out in wave form, will be coherent, but that coherence does not mean "oscillating along *one* smooth curve." Rather, within this framework, coherence means constructively containing *many* synergistic waves. This synergy and capacity to operate with many cooperating waveforms at once is dubbed "harmonic inclusiveness." HRV in such a person would be high. On the other hand, the fewer and lower amplitude the waves, whether representing overall physical activity, heart rate, or biochemical activity, the less synergy, and the poorer the overall quality of health. In this situation, HRV would be low.

On the other hand, in long-term, highly trained meditators, heart rate, breath rate, and HRV drop nearly to zero, making the meditator look close to death by classical biologic measures.[14] Yet meditation is associated with a number of positive health outcomes, including lowering or normalizing of blood pressure, diminished pain, improvement of inflammatory disorders, improved immune function, and improved cognitive function, to name some key changes.[15] [16] [17] [18] [19]

According to these researchers, HRV can be low for one of two reasons. Either there is high true internal coherence, such as a state of bliss and an associated "harmonic inclusiveness in the higher EKG power spectra," or there is a state of extremely poor health and/or negative emotional and cognitive state.[13] [20] According to this model, practicing a meditative technique or a biofeedback tool designed to lock in on one, positive emotional state will produce a regular oscillation of the heart rate and a high HRV, which are healthy psychological changes. But, in order to produce a state of "bliss" with the highest internal coherence (and *lower HRV)*, one must practice a type of meditation or biofeedback which tunes the heart and mind in to multiple frequencies, allowing the body to accommodate multiple, non-destructive nested waves.[20] This flexible, all-inclusive, synergistic state represents, in this view, the highest state of health.

These concepts bear greater exploration and evaluation. Research is ongoing to illuminate further the types of HRV patterns which might lead to greatest health, both psychologically, physically, and spiritually. Until further information is available, a first step toward health would be to take on any sort of meditation practice or biofeedback tool which is likely to help with health, psychological or otherwise. Then, if further exploration of tools and health is desired, one might experiment with Winter's “Bliss-Tuner” biofeedback technology, as referenced below.

Heart Rate Variability and Health

A brief review of the literature reveals that HRV is linked to the overall health of the cardiovascular system and other aspects of health and well-being. Many studies have found that HRV declines with age, potentially as one loses time in deep sleep, and is lower in post-menopausal women than in younger females.[21] [22] [23] [24] [25] Men have higher sympathetic tone and lower parasympathetic tone in general; however, it appears that women, as they age, lose their parasympathetic dominance more markedly than men.[21] Over the last decade, evidence has rapidly accumulated demonstrating that low HRV is an independent predictor of future events and mortality, including cardiac-related sudden death from MI, fatal arrhythmias and all-cause mortality in a number of demographic populations ranging from ICU patients and hemodialysis patients, to middle-aged and older men and women post MI or post cardiac revascularization.[1] [2] [3] [4] [23] [26] [27] A poor HRV profile also helps stratify risk for worsening CHF[28] [29] [30] [31] and risk for developing coronary heart disease in people with diabetes mellitus, type I[6] and even risk for presence of atherosclerotic plaques in otherwise young, asymptomatic adults.[31] Furthermore low HRV and sympathovagal imbalance independently predict worsening atherosclerosis[32] [33] and elevated triglycerides,[34] as well as being correlated with early insulin resistance,[35] obesity,[34] [36] [37] multiple metabolic syndrome,[38] and hypertension.[39] [40]

Interestingly, low HRV and lack of parasympathetic tone also appear to be linked with depression, social isolation, and suppressed anger.[7] [8] [9] [10] This may potentially explain the significantly increased risk for cardiac mortality in depressed individuals post MI. Interestingly, these results seem to be true not only in people with heart disease, but also in a population of otherwise healthy individuals. Stress in general appears to worsen HRV, and has been demonstrated to change short-term HRV profiles more, for example, in surgeons performing higher stress surgeries than in surgeons performing less complicated surgeries.[41] Low HRV also independently predicts complicated recovery after abdominal surgery.[42] On the other hand, working to improve HRV appears to reduce perception of pain.[43]

The literature also points to several interventions, which may improve HRV. In dire circumstances, such as under the threat of a lethal arrhythmia, cardiac resynchronization therapy (pacing) is sometimes necessary.[44] Other medical therapies, including beta-blockers and some calcium channel blockers, appear to be useful in improving HRV.[45] [46] [47] In depressed individuals, selective serotonin receptor inhibitors (SSRIs) and cognitive-behavioral therapy appear to improve HRV,[48] [49] while tricyclic antidepressants lower HRV.[50] St. John's wort caused no change in HRV.[51] Some evidence points to an association between n-3 PUFA (omega-3 poly unsaturated fatty acids, such as those found in fish and fish oil) and improved HRV.[24] [51] Wine, too, appeared to be protective; however, when the association between wine-drinking and fish consumption was controlled for, the independent protective benefit of fish disappeared.[37] [51] Smoking is linked to poor HRV, whereas smoking cessation results in immediate improvements in HRV.[51] [52] [53] The results for exercise have been more conflicted, with some studies showing no or little effect of physical activity on HRV[23] [54] and other studies showing that moderate exercise does improve HRV.[55] [56] A related study showed that those who were already highly trained athletes had a better HRV curve than untrained controls.[57] Multiple studies link particulate from air pollution to poor HRV,[3][58] but it is unclear whether HRV improves if this trigger is removed. While shifting into a hotter or colder ambient temperature shifts heart rate and HRV, in particular, shifting into a cold environment acutely decreases heart rate and raises HRV. It is unclear whether these changes are sustained or whether there is significant health benefit from thermal (or hypothermic) treatments, such as the Polar Bear Plunge.[59]

Finally, there are multiple studies demonstrating that simple mind-body techniques, such as deep, slow breathing, meditating, chanting a prayer or a mantra, or using biofeedback tools can shift HRV and BRS. In some studies, the endpoints were improvements in HRV and BRS themselves.[60][61] In other studies, biofeedback techniques previously shown to improve HRV profiles were then tested for their ability to improve immune function,[11][62] hormone balance,[61] and depression.[63] There are case history data submitted for review which support an improvement in health status and decrease in need for medication in people with chronic fatigue, environmental sensitivities, fibromyalgia, and chronic pain, as well as depression, anxiety, panic disorder, and post-traumatic stress disorder[64] Finally in applied studies in the workplace and educational settings, preliminary data show positive outcomes moving toward greater employee and student health and performance.[11]

Many of the studies on the biofeedback techniques listed above, as distinct from the studies on prayer and deep breathing, have been funded and carried out internally by the Institute of HeartMath and not submitted for external peer review. Furthermore, others of the HeartMath studies have been submitted for peer review, but have not yet been published. Therefore, the trends mentioned for biofeedback need to be evaluated knowing that, except where academic journals are listed, the data have not yet been peer reviewed. Nonetheless, examining both the peer reviewed data and the anecdotal or privately funded evidence together, there appears to be a clear trend toward mind-body techniques having a positive effect not only on HRV itself, but also on associated emotional and cognitive states.

The Basics Matter

In keeping the HRV profile healthy, the most powerful, safe and reliable measures are the simple ones, namely remaining relaxed or consciously developing a positive or appreciative view on life. So be sure to tell your patient that he or she will be practicing *good medicine* by evaluating life and priorities, to see how he or she can maintain happiness, social connectedness, and a healthy dose of relaxation or a sense of ease on a regular basis!

Making Recommendations to the Patient

Given the above data, it is possible to develop an integrative plan to help patients maintain or enhance their HRV. In making an integrative treatment plan, it is wise to ask the following questions for making clinical recommendations: What are the known effects? What are the risks? What is the evidence? What is the cost or the availability? And, importantly, what does the patient believe or value? As a practitioner, your relationship with the patient and your own experience with a particular approach to healing will strongly affect this last point. For that reason, you may want to experiment with several of these approaches yourself before talking to patients about them. Not only will you have the chance to improve your own health and well-being, but you will also have a personal experience which allows you to step on a common path with the patient, as you both move toward greater health. This kind of mutual and personal teaching honors the spirit of integrative medicine, in which the health and wisdom of both patient and health care practitioner are important, indeed critical to healing! Luckily, many of the approaches listed below are fun! You may even want to try them with your office staff or at home for your own learning.

Steps to Enhance Heart Rate Variability

Remember that patients do not need to attempt to try all or even most of the following therapies right off the bat. It is generally wise to suggest that they pick a few that appeal to them and try them out rather than overloading them with new things which they need to learn and to which they need to adapt. Patients can always take on more approaches and/or modify and remove ones they like less well as they get to know their own needs.

Step 1: Follow Good Preventive Measures

- Quit smoking.
- Maintain a healthy weight.
- Keep cholesterol in check.
- Eat a diet rich in omega 3 fatty acids, either from fish or from fish oils. (see Chapter 88 , The Anti-Inflammatory Diet.)
- Keep alcohol consumption moderate.
- Exercise regularly but moderately, with guidance from a physician if heart disease or other significant illness is present.

Step 2: Maintain a Healthy State of Mind

for sympathovagal balance and emotional well-being

- Keep up social connections—or make new ones, drawing on friends, family, or social organizations whenever possible. Healthy relationships are powerful determinants of heart health.
- Get professional help from a psychologist, psychiatrist or other counselor if you have more serious symptoms of depression or anxiety.
- Develop practices which help you relax. (see Chapter 95 , Prescribing Relaxation Techniques.)

Deep, Slow Breathing

It is cheap, safe, and very easy to perform with no extra equipment and little time. The best results come when subjects maintain a breathing rhythm of 6 breaths/minute.

Meditation…

whether walking meditation, mindfulness meditation, chanting, or any other form that is appealing.

Prayer…

either on your own or in a group for the social connection!

Journaling…

even writing down a few words and phrases per day can be healing.

Biofeedback

There are several good, computerized tools on the market to help you learn to use biofeedback.

- www.wilddivine.com A visually intriguing computerized adventure, driven as you learn skills to control your bodily rhythms through biofeedback.
- www.heartmath.com An organization which provides literature, biofeedback hardware and software, and training for health care professionals and lay people.
- www.soulinvitation.com The Bliss-Tuner is a novel, in-depth computerized biofeedback program which can be ordered for home use. The literature is extensive and the program is more complex than many will want to work with, although it claims to entrain "harmonic inclusiveness" for optimum health, as discussed above.

Guided Imagery

Excellent resource for tapes or CDs are:

1. www.healthjourneys.com or
2. www.interactiveimagery.com for professional training in guided imagery

Step 3: Consider Medical Therapies and Supplements

- Beta-blockers, verapamil (and possibly other calcium channel blockers), and anti-arrhythmics may improve HRV, but must be guided by a doctor
- For depression, tricyclics appear to worsen HRV whereas SSRIs appear to improve it. St. John's wort had no (measurable) effect on HRV.

A Simple Beginning

In the office, the simplest and safest way to help patients to begin enhancing HRV is to teach them a simple deep-breathing technique.

1. Have the patient place a hand on his or her belly—while you demonstrate!
2. Make sure to have him or her "deep belly breathe" so that the stomach rises on the inbreath. On the outbreath, the belly should fall.

3. In general, have the patient aim to breathe out for twice as long—or whatever he or she can sustain, as compared to the inbreath. A 4 to 8 count, for example, works well.
4. Have the patient repeat this twice a day, morning and night, or whenever stress arises, for about 5 minutes to train the body-mind.

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