Using Heart Rate Variability to Improve Diagnosis and Care of At-Risk Patients

Interview by S. Granville Vance, MD and Daniel N. Weiss, MD, FACC

This article features a discussion between S. Granville Vance, MD and Daniel N. Weiss, MD, FACC about heart rate variability (HRV) testing. Dr. Granville Vance is full partner and lab director of Dillon Family Medicine in South Carolina; their private, seven-provider family practice was the first to purchase the PD2i Analyzer™ technology. Dr. Weiss is chief medical officer of Vicor Technologies; their PD2i® nonlinear algorithm and software is used to stratify patients at risk of sudden cardiac death or autonomic nervous system dysfunction.

Part 1: Dr. Weiss Interviews Dr. Vance

Dr. Weiss: What is your perception of how primary care providers address the autonomic health of their patients?

Dr. Vance:

I believe physician consideration of autonomic health and its care implications is an important component of patient care that is often overlooked by those of us in primary care. This is partly due to our sometimes faded knowledge of autonomic nervous system (ANS) function, a lack of understanding of the many care opportunities for those with ANS dysfunction, and, lastly, a lack of awareness on the part of most primary physicians of how easily and affordably heart rate variability (HRV) may be measured to identify ANS dysfunction. HRV testing should be a common office service, as early identification and proper treatment can improve patient care and outcomes, yet it is rarely performed.

Dr. Weiss: What would you tell the physician reluctant to incorporate testing for autonomic nervous system dysfunction?

Dr. Vance:

I would seek to educate them as to the many reasons it is important to identify those in our practice, mostly diabetics, whose care would change by our ability to identify ANS dysfunction. Let me list a few reasons and how they are addressed in my practice:

Hypoglycemic unawareness. The patient with autonomic impairment may not experience the early symptoms of sweating or rapid heat rate before developing a dangerously low blood glucose that could cause a serious injury to themselves or others. I make sure the patient and family understand this potential event, while recommending liberal glucose testing, and consider less than "tight control" our goal.

Increased risk during surgery. Peri-operative cardiac morbidity and mortality in diabetics with cardiac autonomic neuropathy (CAN) are increased two to three times over non-diabetics. These patients receive close scrutiny in their pre-operative assessment and during their hospitalization. Additionally, I notify anesthesia that these patients may need more vasopressor support and are more prone to hypothermia during the operative period.

Silent MI. Because of the reduced appreciation of cardiac ischemic pain in persons with CAN, underlying cardiac disease may be associated with only minimal symptoms. Silent MI is twice as prevalent in diabetics with CAN. Vague symptoms, such as cough, unexplained nausea, unexplained dyspnea, new fatigue, or subtle ECG changes, should prompt the physician to evaluate for ischemia with extra caution in this diabetic subset, as their mortality rate is more than double those without CAN. In summary, silent MI is twice as common and twice as fatal in a diabetic with CAN.

Orthostatic hypotension. Persons with CAN should be educated that they are at risk of excessive blood pressure drops upon standing. Symptoms may include dizziness, weakness, near-fainting, vision loss, or even frank syncope. One sees this frequently in longstanding diabetics and octogenarians. This is also a common manifestation of Parkinson's disease, as the central components of the ANS are damaged. In addition to education, interventions include mineralocorticoids, sympathomimetic agents, caffeine, B-adrenergic blockers, DDAVP, pressure graduated stockings, and liberal salt and water intake. These patients should be advised to take extra precautions with hot showers and baths, during warm weather, after exercise, and when they have a fever. We prescribers should be cautious with anti-hypertensives, anti-anginals, antidepressants, and diuretics that may worsen the symptoms.

Resting tachycardia. CAN patients may have resting heart rates of 90 to 100 beats per minute that is often unresponsive to exercise. This needs to be addressed medically (with beta-blockers) in patients with known coronary disease and not confused with hyperthyroidism, postural orthostatic tachycardia syndrome, anxiety, or de-conditioning.

Guided exercise programs. Persons with CAN need to use their "perceived" level of exertion — not their heart rate — to guide their intensity of exercise. Many persons with CAN are unable to reach the target percentage of their age-adjusted maximum heart rate. Attempting to do so might induce a cardiac event or syncope. I consider stress testing in these at-risk patients before endorsing an exercise plan.

Prescribing implications. Knowledge of abnormal ANS function prompts me to review current medications (Figure 1) for

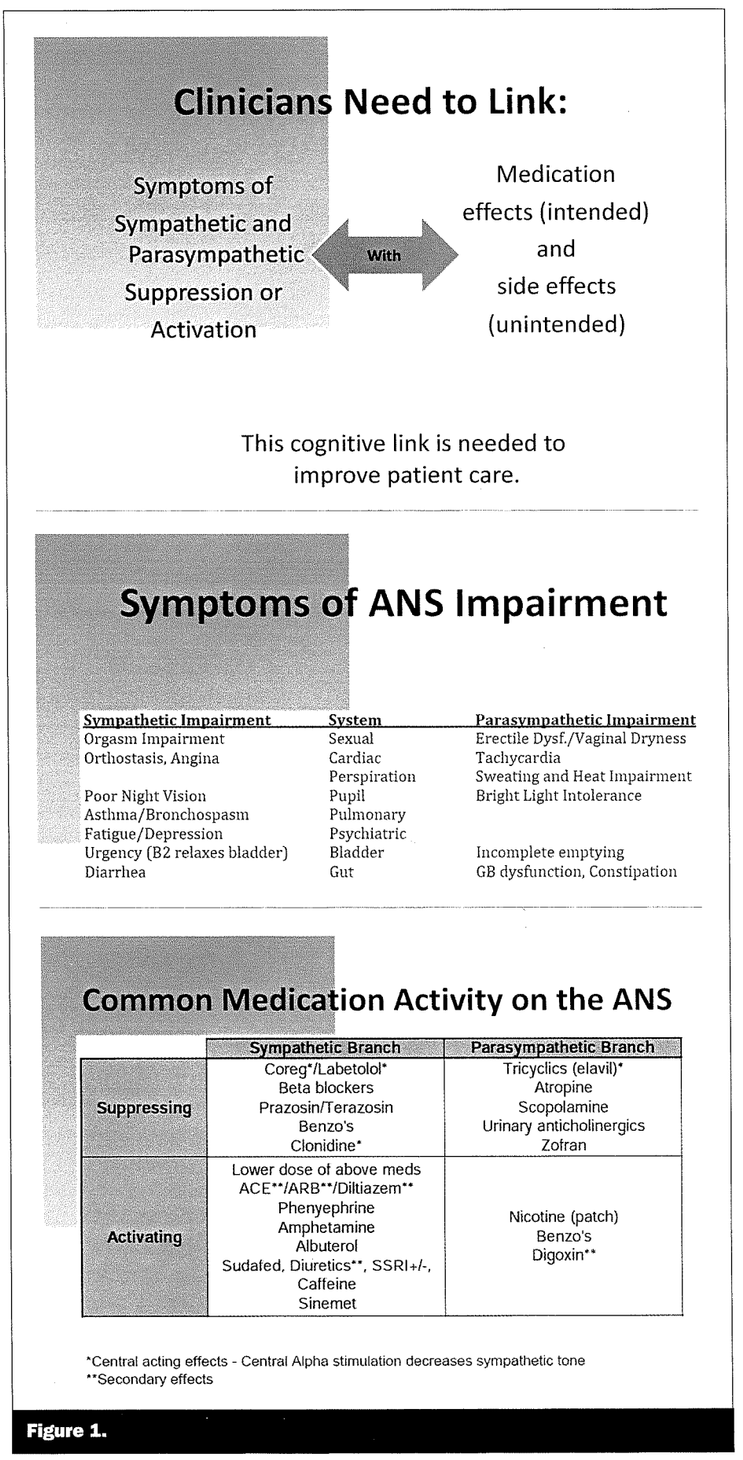

Figure 1.

possible causation, while prescribing new medications with heightened ANS awareness. I am particularly inclined to address medications if symptoms of ANS dysfunction (Figure 2) are identified and correlate with abnormal test results.

Dr. Weiss: How is HRV testing performed in your clinic?

Dr. Vance:

I use the PD2i Analyzer™ (Vicor Technologies, Boca Raton, FL). The PD2i Analyzer™ displays and analyzes electrocardiographic data to provide a measure of HRV in patients at rest, and during controlled exercise and paced respiration. The digital collection device includes 12-lead ECG functionality as well. The test is administered by a non-licensed medical assistant over a 20-minute period. The raw data collected during patient testing is transmitted via the Internet to Vicor for analysis. The data is processed and the results are received within 60 seconds as a three-page document that provides visual and numeric data for physician interpretation. The HRV testing is performed in my office as a scheduled 30-minute office procedure. The patient is seen after the study as part of a planned visit or they are called to return for discussion of the results if they are abnormal. I have the nurse inform those with normal HRV testing by telephone or mail.

Persons with diabetes, hypertension, and coronary artery disease constitute the bulk of the testing in my practice.

Dr. Weiss: What has been your experience with reimbursement?

Dr. Vance:

Testing for HRV has reimbursed almost without incident, as we learned which companies require a prior authorization or rarely disallow the service for a certain diagnosis. Diabetes is always covered. A hypertension diagnosis was not covered by one private insurance company. Reimbursement information is found in the "Resource Manual" provided with the PD2i Analyzer™. More than 95 percent of our charges have been processed without a request for medical necessity or records. We are able to bill SC Medicaid using the CPT codes 95921, 93040, and 99211. We received a payment of $83.80 for 93040. SC Medicare allows $86.70 for 95921 and 99211. More than 10 private insurance companies have reimbursed the CPT code 95921 singularly, with payment ranging from $56.08 (United Healthcare) to $77.00 (BC/BS). The fee to Vicor Technologies for each test is $25.00, billed monthly. Consumables are less than $2.00 per test.

Dr. Weiss: Have you incurred additional costs to conduct the PD2i Analyzer™ test?

Dr. Vance:

We drew on the excess capacity in our administrative area. Specifically, we trained two non-degree staff members who now very competently administer the test. They rotate on the testing schedule and if there is a scheduling gap or no-show, they simply return to their administrative activities. This has allowed us to add a service without adding staff expense. Based on the patient insurance demographics of our practice, a physician performing two tests per day, 250 days per year would generate more than $25,000 profit per year, net of staff and consumable allocation. As you can see, HRV testing with the PD2i Analyzer™ enhances patient care and adds substantially to the bottom line of the physician practice.

Dr. Weiss: With regard to the Ewing and Valsalva maneuvers, which are integral to the CPT code 95921, how do the tachograms display the physiologic response?

Dr. Vance:

The Ewing maneuvers reflect the interplay of the sympathetic and parasympathetic nervous system. Specifically, the deep, rhythmic breathing, which is predominately parasympathetically mediated, provokes a normal slowing of the heart rate (increasing the R-R interval) during the expiratory phase of deep breathing. This is largely mediated through thoracic baroreceptors.

The robustness of the ANS is most evident with the initial R-R rise at the beginning of the Valsalva maneuver, due to parasympathetic activation. This is followed by parasympathetic withdrawal during a transition to sympathetic activation at the later stages of the Valsalva. Loss of the "overshoot" immediately following the Valsalva release appears to be an early indication of HRV decline.

The standing maneuver is predominately a sympathetic response reflecting the ability of a healthy ANS to almost instantaneously increase the heart rate upon standing, with a return to a new, approximately 10 BPM higher, baseline, as the vascular beds respond with vasoconstriction over the next several seconds.

Dr. Weiss: Are there other ways you manage your patients differently?

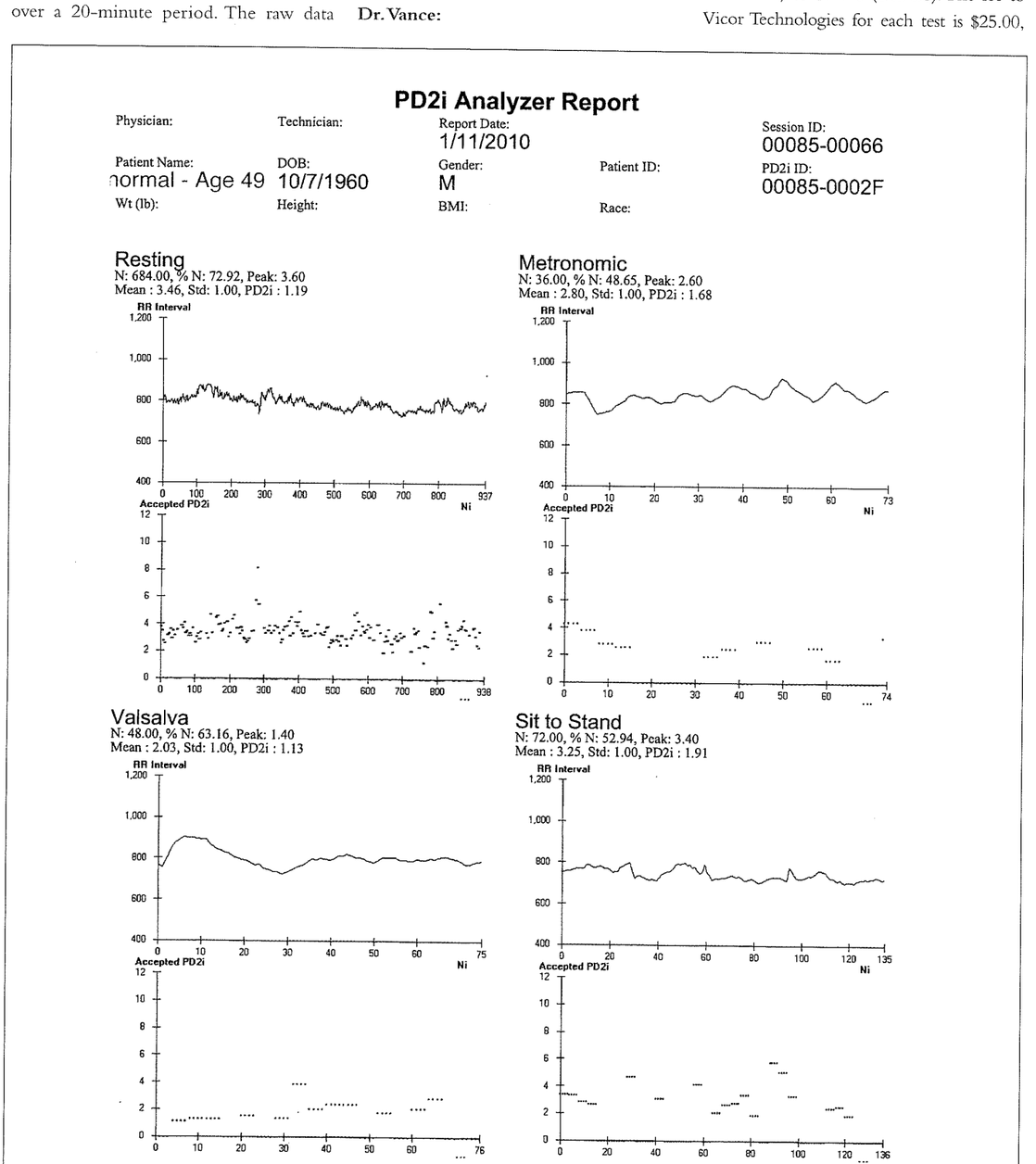

Figure 2.

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Dr. Vance:

We prescribers need to link our patients' symptoms of ANS dysfunction (Figure 2) with the intended or unintended effects of medications (Figure 3). I have begun inquiring more about fatigue in my patients on beta-blockers. If they are reporting fatigue, I have found I can usually reduce their beta-blocker while maintaining heart rate and angina control with a resultant improvement in their fatigue. The incorporation of HRV testing has enabled me to reduce the use of diuretics. I have decreased the number of my patients on fixed doses of diuretics to reduce sympathetic tone. Most patients, not all, are capable of adjusting their diuretic use around a target weight or as guided by their signs and symptoms of edema and dyspnea.

Dr. Weiss: How have your patients received this relatively new office evaluation?

Dr. Vance:

Very well. Most are fascinated to learn the brain and heart are intimately communicating, and the graphic display enables them to see how quickly their heart rate can respond to simple maneuvers like deep breathing or standing. For those patients with abnormal PD2i Analyzer™ results, I have found that learning that their nervous system is not functioning properly is quite motivating.

Part 2: Dr. Vance Interviews Dr. Weiss

Dr. Vance: What is the current understanding of how the brain interacts with the heart?

Dr. Weiss:

It has become very clear that the autonomic nervous system plays a crucial role in cardiac disease, in both ischemia (*e.g.*, via coagulation system effects) and arrhythmogenesis (*e.g.*, via altering cardiac electrical properties such as conduction and refractoriness). Since the variation seen in heart rate is due to autonomic influence, we can view that heart rate variation as a signal, process it using mathematical tools, and draw conclusions about the autonomic nervous system and, by extension, overall cardiac health and the risk for future adverse events. While several such mathematical tools exist, the PD2i® has demonstrated consistent accuracy.

Dr. Vance: What exactly does the PD2i® measure?

Dr. Weiss:

On a strictly mathematical level, the PD2i® algorithm measures the degrees of freedom that exist at any moment in time of a nonlinear system; that is, the degree of relative independence of the different components that make up that system. It's sometimes easier to think of it in its inverse, that it measures the degree of cooperativity among those components. When the degrees of freedom (as measured by the PD2i®) are high, it suggests that the different components are acting relatively independently or with minimal cooperativity; when low, it suggests relatively little independence and a high degree of cooperativity.

Dr. Vance: So how does this correlate to actual physiology?

Dr. Weiss:

There are at least six known sensorymotor loops in the central nervous system that affect heart rate, including temperature, pH, baroreflex, etc. Each of these may "want" the heart to beat at a specific rate at any given moment. Since an individual ultimately has one heart rate, not six, those inputs are integrated in some way, but the "footprints in the sand" of the struggle between them is the heart rate variability. The more independently they act, the higher the PD2i® value at that moment; the more they cooperate, the lower the PD2i®. High sympathetic tone tends to lower the degrees of freedom and the PD2i®, while high parasympathetic tone (or blocking sympathetic tone) raises it.

Dr. Vance: How does this tell us about the relative health of the autonomic nervous system?

Dr. Weiss:

Well, as you can imagine, if the ANS is not functioning properly, the baseline resting PD2i® should be different from normal. Perhaps as important, the ANS's response to stressors should also be different. There are several stressors with known effects on the ANS that can be performed. One set of stressors is known as the Ewing battery, which includes the Valsalva maneuver, metronomic breathing, and orthostatic stress. So, by measuring the PD2i® values seen in response to these maneuvers and comparing them with the PD2i® values obtained from individuals without ANS disease, it may be possible to make inferences about the overall health of the ANS.

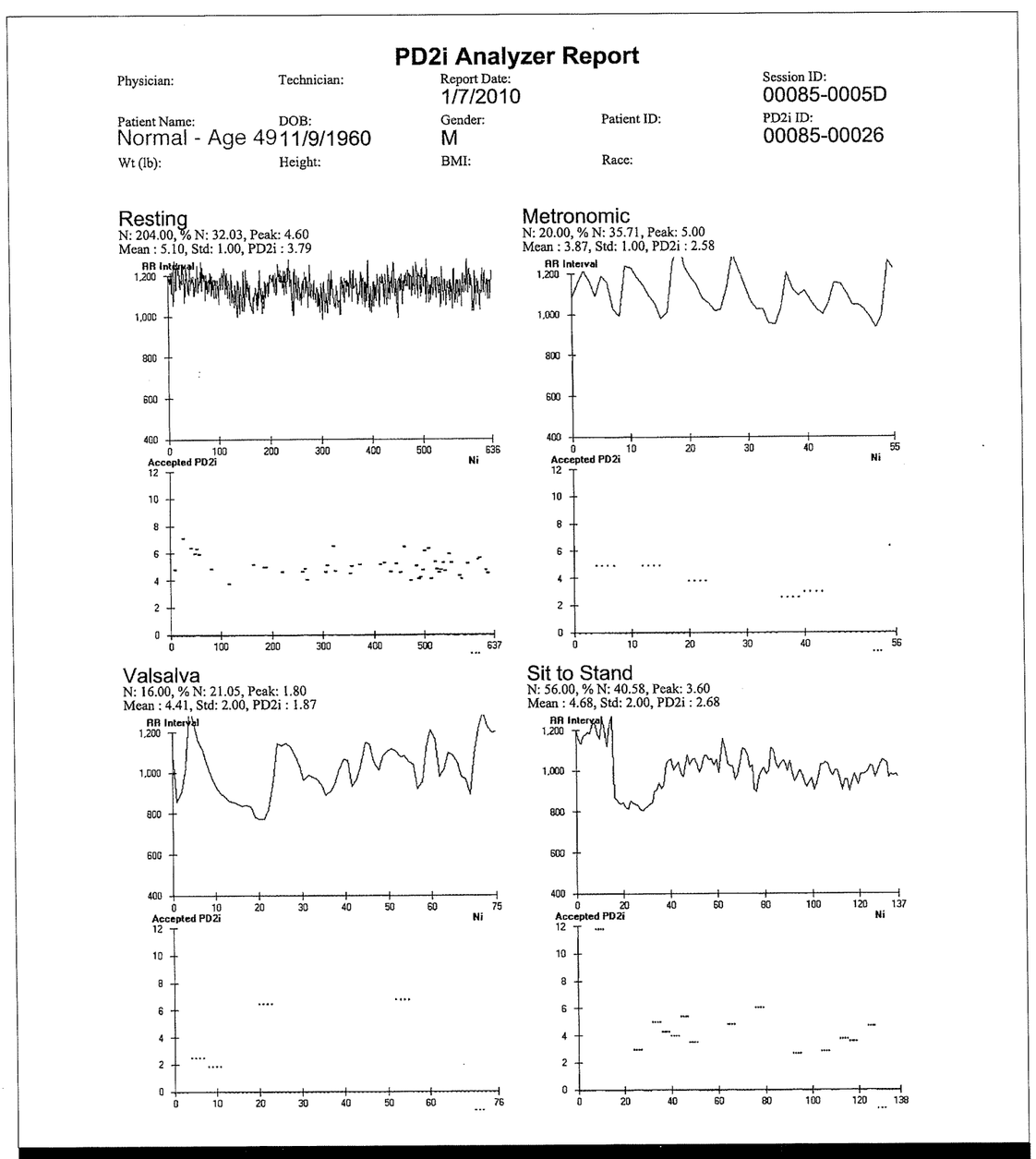

Figure 3.