Thoughts on ECG in cardiovascular disease and accessibility to portable ECG testing

Cardiovascular disease (CVD) continues to be the leading cause of death in the United States. In addition, more than one-third of U.S. adults have at least one type of CVD, and about one in three deaths in the U.S. are attributed to CVD. It is not at all unusual to know personally someone suffering from CVD or who experienced sudden death due to a cardiac disorder. Sometimes CVD occurs without expressing symptoms. However, electrical system to the heart malfunctions and abnormalities may have been present and detectable via an electrocardiogram (ECG).

The ECG is a non-invasive medical test that detects cardiac abnormalities by measuring the electrical activity generated by the heart as it contracts. The ECG is crucial in detecting cardiac arrhythmias and myocardial infarction. It may also help to identify other CVD including cardiac hypertrophy, heart inflammation, coronary artery disease, heart failure, and electrolyte imbalance, etc. The ECG has become the most commonly conducted cardiovascular diagnostic procedure and a fundamental tool in clinical practice. Once CVD is detected, it is possible for health care providers and patients to determine the appropriate course of action: for example, certain lifestyle changes are implemented, medications are taken as prescribed and interventional cardiac procedures or surgeries are performed as recommended.

Long wait times for physician's appointments are certainly ill-advised for patients who have conditions that require cardiac monitoring. Besides, having a normal ECG in a physician's office does not rule out potential serious heart disease since a patient may be asymptomatic in the physician's office, and yet experience symptoms elsewhere. Patients may have transient abnormalities that tend to come and go, and thus ECG recordings in physicians' offices can be quite normal between episodes. Intermittent abnormalities may occur only under certain conditions. Thus, if the patient has access to a portable ECG device, the patient can initiate an ECG check when certain signs and symptoms appear, which may be heart-related, such as palpitations, chest pain, shortness of breath, fainting, lightheadedness, prolonged fatigue, dizziness, racing heart, irregular heart rate, and near-syncope. Moreover, when the patient shows the ECG recordings during the next physician's visit, the physician can correlate the patient's ECG with the patient's notation of symptoms -- information that is crucial for an accurate diagnosis. Some portable ECG devices have algorithms for automated ECG interpretation such as atrial fibrillation (AF) evaluated by sensitivity and specificity. Some portable ECG devices allow their users to transmit their ECGs to their physicians by smartphones. Thus, patients may receive more rapid diagnoses from their physicians, alerting them to potentially serious cardiac problems. Potable ECG devices can also be used to track the effectiveness of drugs, and to monitor the status of the heart prior to and after interventional cardiac procedures or surgeries. Thus, easy access to portable ECG devices can increase diagnostic capability for early detection of CVD, reduce health care costs, identify patients in early stages of cardiac risk, and facilitate the necessary treatment earlier in order to prevent significant cardiovascular events such that morbidity and mortality may be reduced.

There are now some 1-lead handheld ECG devices available over-the-counter (OTC) for personal and home use for basic heart monitoring and to check for cardiac arrhythmias during uncommon cardiac events. The 1-lead handheld ECG devices are pocket-sized and have their own built-in displays. Some of these devices work with smartphones or tablets, and are useful for determining AF that is not always detectable to the patients. AF can lead to stroke, heart failure and other related heart problems if patients are not treated in a timely and effective manner. The algorithms for expanding automated real-time interpretation via handheld ECG devices are still a work-in-progress. In my opinion, 1-lead handheld ECG devices could be improved with additional monitoring functions such as heart rate variability (linear and nonlinear), ventricular repolarization duration variability (RDV), ST segment abnormality (elevation or depression) and T wave alternans, as well as other arrhythmias such as premature ventricular contraction, monomorphic ventricular tachycardia, Torsades de pointes, ventricular fibrillation, atrial flutter, atrioventricular nodal re-entry tachycardia, Wolff–Parkinson–White syndrome, atrio-ventricular block, sinus arrest, and long QT syndrome. We have separated the RDV spectra into physiology-related and pathology-related parts, which are helpful in the evaluation of patients with myocardial infarction, as well as in research using drug-free, heart failure dogs. The dynamics of QT interval

include important and valuable diagnostic and predictive information that have been neglected.

A 12-lead ECG records bipolar and unipolar potential differences from 12 different views of the heart, and provides a complete picture of cardiac electrical activity. The 1-lead ECG has inherent deficiencies compared to a 12-lead ECG and will miss heart attacks and other cardiac problems. Moreover, abnormalities in the precordial and other leads might not be detected with a 1-lead ECG. Thus, a 12-lead ECG would help to identify more types of CVD. Not surprisingly, physicians prefer to interpret a 12-lead ECG rather than a 1-lead. The standard 12-lead ECG is indispensable for clinical diagnosis and immediate initiation of therapy in patients with acute ischemic heart disease and serves as the criterion standard for diagnosing arrhythmias and conduction disturbances.

Today, technology allows for the 12-lead ECG devices to be small and portable. It is my hope that 12-lead portable ECG devices will receive OTC clearance from the Food and Drug Administration (FDA) in the near future, so that patients can record 12-lead ECGs at any time and from anywhere (at home, at the office or in the gym). If patients maintain time-based records of symptom-occurrences and corresponding activities, as they should, then during ensuing physician visits, the 12-lead ECG recordings can be viewed by physicians for interpretation. Thus, physicians will have more comprehensive information about patients' heart health, facilitating a better understanding of symptom genesis, which could lead to improved treatment options. Currently, the 1-lead device is the only one available OTC, and accordingly should still be used. I must note that 1-lead handheld ECG devices could also be used to accomplish full

12-lead recordings in a sequential manner to obtain "12-lead equivalent" ECG recordings. However, this would surely be more complicated for patients to use than a standard 12-lead ECG device and would not permit simultaneous readings during a transient episode of symptoms.

We have done much work related to ECG and cardiac electrophysiology in normal subjects, patients with CVD, and research animal models (dogs and rabbits). Cardiovascular research in electrophysiology contributes to our understanding of cardiac electrical activity in normal physiological and pathological conditions. Finally, I would like to emphasize that it is important to educate the patients in the correct use of OTC or prescribed ECG devices, pointing out that in case of medical emergency, patients should go directly to the hospital emergency room or call 911. We should inform patients in such a way that they are comfortable using these devices, whether OTC or prescribed. In addition, utilization of portable ECG testing must insure patient safety and privacy by stressing the importance of full compliance with the FDA human subject protection regulations, the Health Insurance Portability and Accountability Act (HIPAA) privacy rule, and other related regulations.

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