EDITORIAL

A Renaissance in Electrocardiography

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Electrocardiography began more than a century ago when Waller and Einthoven introduced the electrocardiogram (EKG(Dutch); ECG (English)) for registering the electrical activity of the heart from the surface of the body. The evolution of electrocardiography can be categorized into three phases:¹ the Introductory Phase (1890–1940) began with the invention and progressed as technical improvements were added and numerous descriptive reports relating ECG findings to specific cardiac disorders were published;² the Diagnostic Phase (1940–1990) started with the introduction of the full 12-lead ECG (1942) and grew as the 12-lead ECG and dynamic exercise and Holter recordings became widely used and accepted in the everyday practice of clinical medicine and cardiology; and³ the Renaissance Phase (since 1990) reflects a new appreciation of the ECG as an invaluable tool for providing fundamental insight into the basic electrophysiology of the heart in health and disease in the current era of molecular genetics and electrical device therapy.

The Renaissance Phase draws heavily on the earlier clinical accomplishments and technical improvements during the 50-year Diagnostic Phase beginning in the 1940s. Although the ECG became a widely accepted diagnostic tool, new invasive diagnostic techniques such as programmed electrophysiologic testing were introduced in the 1980s. This "new kid on the block" held great promise for identifying patients at risk for sudden cardiac death. Classical electrocardiography was thought to have achieved almost its entire potential, and the general feeling was that it was time to move on to new and more sophisticated diagnostic electrical techniques. Furthermore, the introduction of new electrical therapy with pacemakers and exter-

nal defibrillators in the 1960s and implantable defibrillators in the 1980s ushered in a new focus on electrical therapy that stole the thunder from the "old fashioned" 12-lead diagnostic ECG. Teaching of electrocardiography to medical students diminished as electrocardiography went digital and diagnostic interpretation of the ECG was automatically printed out on the paper ECG. Clinicians lost the excitement of deductive reasoning in the analysis and interpretation of the ECG.

But something changed in the 1990s that initiated a renaissance in electrocardiography. In 1991 Keating et al. reported a genetic linkage between a locus on chromosome 11 and QT prolongation in a large kindred with Long QT Syndrome (LQTS).¹ The ECG-QT interval was used to classify patients into those who were affected and unaffected by LQTS so that the gene locus could be identified. This approach was quickly applied to other large families with LQTS, and since the early 1990s six ion-channel genes have been identified. These findings have provided substantial gains in knowledge about basic physiology of ion channel function in the myocardium. Almost concurrently, it was recognized that certain drugs such as terfenadine, erythromycin, cisapride, and others could produce acquired QT prolongation and result in life-threatening torsade de pointes-type ventricular arrhythmias similar to those seen in hereditary LQTS. The ECG became an essential tool for identifying drug-induced repolarization abnormalities, and regulatory agencies throughout the world established electrocardiographic guidelines for safety screening of new chemical entities (drugs) before they could be approved for clinical use.² These activities led to new approaches for quantifying ventricular repolarization including QT/RR relationships and T-wave morphology.

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But that was just the beginning. The ECG became a key tool in the diagnosis of several other genetic disorders including hypertrophic cardiomyopathy,³ Brugada Syndrome,⁴ and arrhythmogenic right ventricular dysplasia.⁵ In each of these disorders, the ECG pattern was essential in identifying the genetic mutations responsible for these conditions.

The Q wave diagnosis of myocardial infarction and localization of the infarct to specific regions of the myocardium were established during the last half of the 20th century. So what contributed to a renaissance in this area of electrocardiography? New therapy with thrombolytics and angioplasty highlighted the need for accurate and early diagnosis of acute coronary syndromes so that the ensuing infarction from coronary thrombosis could be quickly reversed. The ECG was the key tool, and the coupling of ECG diagnosis with new and effective acute coronary therapy propelled electrocardiography to new heights. Precise localization of infarction-related wall motion abnormalities with angiography, echocardiography, and magnetic resonance imaging permitted improved anatomic correlations with ECG Q waves and ST and T-wave findings. An article in this issue of *Annals* by Bayes de Luna and his associates highlights these new associations through correlations of the site of coronary occlusion with injured segments of the heart.⁶

During the past few years, life-saving therapy with the implanted cardioverter defibrillator (ICD) has been documented in high-risk coronary patients, with a greater beneficial effect in patients with wider QRS complexes.⁷ A wide QRS complex is now used to select patients with advanced heart failure for cardiac resynchronization therapy. The QRS duration on the ECG is now in prime time, and its importance in selecting patients for electrical therapy has contributed to the recent renaissance in electrocardiography.

Since its introduction, the ECG has been widely used in the diagnosis of atrial fibrillation, a common arrhythmia complicating rheumatic heart disease during the first half of the 20th century. As rheumatic heart disease came under control, atrial fibrillation declined dramatically in the younger age groups. Currently, intermittent and chronic atrial fibrillation rhythms are most frequent in older patients, with the arrhythmia associated with systemic emboli. Although there are now ablation techniques for eliminating atrial fibrillation, this

rarely works in the older age group. Rather, the current focus is on prompt detection of atrial fibrillation so that prophylactic anticoagulation can be initiated. Once again, there has been resurgence in electrocardiographic detection of atrial fibrillation with increasing reliance on both static and dynamic electrocardiography.⁸

The new interest in electrocardiography is well justified, for this 100-year-old technique is now centerpiece in the accurate diagnosis of a wide variety of cardiac disorders. It is increasingly utilized in safety monitoring of new and established drugs and in the selection of patients for cardiac electrical therapy. The electrocardiographic recording of P, QRS, ST, and T waves and of cardiac arrhythmias has taken on new meaning, and all this has contributed to the current renaissance in electrocardiography. This renaissance is well documented by the remarkable turnout of interested cardiologists in the ECG case-discussion sessions at the International Society for Holter and Noninvasive Electrocardiology meeting this past year in Buenos Aires. As an outgrowth of this interest, Dr. Antonio Bayes de Luna, an associate editor of *Annals*, will initiate in the near future an on-line web-based course in electrocardiography.

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