REVIEW ARTICLE

The Year of 2012 in Electrocardiology

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surface electrocardiogram; important contributions in 2012

INTRODUCTION

Since my first assignment in 2005 to review for ANE the year's most important publications on 12-lead electrocardiograms (ECG),¹ this task is getting more and more difficult. It is hard to believe, but the number and quality of investigations describing new and exciting information derived from this classic and "old" diagnostic procedure is increasing every year. My hands have been tied over the years as I had to limit the number of publications to 50. Thus, all I can do is to hail the authors whose publication is being reviewed here and apologize to the others whose papers, probably not less important than the others, are not among the reviewed articles.

Early Repolarization (ER)

Heng et al.² reevaluated in an apparently healthy white population the prevalence of J-point elevation with or without ST junction (STj) elevation; the authors demonstrated a significantly prevalence of this syndrome according to the inclusion (2.1%) or exclusion (29.3%) of STj elevation and stressed the influence of end QRS notching or slurring on the definition of ER. Modulation of the J-wave elevation by vagal activity was observed by Mizumaki et al.³ who connected this with the occurrence of ventricular fibrillation (VF) predominantly at night with idiopathic VF. In African Americans with ER and ST elevation, were followed for an average of 7.6 years by Perez et al.⁴ and was found not to be predictive of cardiovascular death.

Roten et al.⁵ described the class 1a anti-arrhythmic drug ajmaline attenuates ECG characteristics of inferolateral ER: the drug significantly decreased the J-wave amplitude in ER and prolonged the QRS width significantly less than in patients with Brugada syndrome (BR). This indicated a different pathogenesis for both disorders. Also in Wolff-Parkinson-White syndrome, a high prevalence of J-waves were found, frequently disappearing after catheter ablation.⁶ Rosso et al.⁷ found that the combination of J waves with horizontal/descending ST segment improves the ability to distinguish patients with high risk for VF.

Perez-Riera et al.⁸ found that convex upward J waves, with horizontal/descending ST segment or "lambda-wave" ST shape are suggestive of idiopathic VF and could identified mutations in the genes with ER abnormalities. Lanza et al.⁹ prospectively studied 4176 subjects without heart disease: typical ER pattern and J wave were common in subjects with lower heart rates and were not associated with symptoms potentially related to arrhythmias.

ER and Acute Myocardial Infarction (AMI)

In patients following an ST-elevation acute myocardial infarction (AMI) the presence of ER was associated with a higher incidence of ventricular arrhythmias.¹⁰ Twelve lead ECGs before AMI onset could be evaluated by Naruse et al.¹¹ in 220 consecutive patients with AMI; ER in these ECGs was an independent predictor of the occurrence of

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VF/fibrillation in the very early phase (within 48 hours) of the acute infarction.

The differentiation of the ER pattern from ST-elevation in AMI may frequently pose a problem; the ER patients had a higher R-wave amplitude, smaller ST-elevation, and shorter QTc.¹²

In a population-based study, ER pattern localization, J-point elevation amplitude, or T-wave morphology did not distinguish benign from malignant form of this pattern. ER pattern with notching and horizontal/descendant ST segments was associated with the highest risk of all-cause and cardiovascular deaths. Conversely, a slurring ER pattern or ascendant ST segment was not associated with increased mortality.¹³

Cardiac Resynchronization Therapy (CRT)

In contrast to previous data, Dupont et al.¹⁴ found the QRS morphology to be a more important baseline ECG determinant of the clinical outcome of patients with CRT, than the QRS duration. According to the authors, the echocardiographically determined change in ejection fraction in patients with LBBB and QRSd ≥ 150 ms was better, than in those with LBBB and QRSd < 150 ms; long-term survival was also better in LBBB patients with QRSd ≥ 150 ms, but this difference was not significant; apparently comorbid conditions may confound the treatment responses. Hsu et al.¹⁵ found that QRS duration ≥ 150 ms and LBBB are among the six predictors of a super-response to CRT.

A shorter QRS duration during left ventricular (LV) pacing and, in particular, a shorter LV paced than RV paced QRS width, were strong and independent predictors for response to CRT.¹⁶

Patients undergoing CRT with defibrillator were followed by Friedman et al.¹⁷ for sustained ventricular arrhythmias. The authors found a significantly increased 3-year incidence of ventricular arrhythmias in those with LV end systolic diameter > 61 mm, as compared to a lower incidence among those with a less dilated ventricle. The REVERSE study demonstrated that among over 600 patients with CRT with mild heart failure, LBBB, and QRS prolongation were markers of reverse remodeling and clinical benefit.¹⁸

In patients with LBBB and heart failure with CRT body surface potential mapping demonstrated reduced ventricular repolarization parameters QT_m, QTc_m, and QTD global/regional values.¹⁹

CARDIOMYOPATHY

In patients with primary cardiomyopathy with excessive trabeculations (called also noncompaction cardiomyopathy) a high prevalence of ER was found, especially in those who present with malignant ventricular arrhythmias.²⁰

Signal-averaged ECG parameters, as a filtered averaged QRS (fQRS), low amplitude signal duration < 40 mV and root-mean-square voltage in the last 40 ms of the QRS were studied by Santangeli et al.²¹: abnormal parameters were a reflection for the presence of extensive cardiomyopathic involvement of the right ventricular outflow tract (RVOT).

Diabetic patients with nonischemic cardiomyopathy benefited from better results of CRT than ones with the ischemic type of the disease.²² In ischemic cardiomyopathy Brenyo et al.²³ found that fragmented QRS, especially identified in inferior leads, is predictive of SCD, SCD or appropriate ICD shock, and all-cause mortality in patients with ICM. In both types Pei et al.²⁴ concluded that the presence of J wave or fQRS in the inferior leads predicted higher risk of SCD.

Acutely exhibited transient J wave preceding ST segment elevation in a postmenopausal woman with Takotsubo cardiomyopathy (TC) and acute chest pain, in the authors' opinion suggests that ischemia may account for the J wave appearance as a sign of an ongoing TC.²⁵

Brugada Syndrome (BS)

Veltman et al.²⁶ correlated the location the Brugada type I ECG performed by using 12 right precordial leads with cardiovascular magnetic resonance imaging (CMRI). In all patients, Brugada type I pattern was found in the 3rd inter-costal space. ICS in sternal and left-parasternal positions. RVOT extent determined by using CMRI included the 3rd ICS in all patients. Maximal RVOT area was found in 3 patients in the 2nd ICS, in 5 patients in the 4th ICS, and in 27 patients in the 3rd ICS. CMRI predicted type I pattern with a sensitivity of 97.2%, specificity of 91.7%, positive predictive value of 88.6%, and negative predictive value of 98.0%. Maximal RVOT area coincided with maximal ST elevation in 29 of 30 patients. Lead positioning according to RVOT location improves the diagnosis of BS.

QT-interval

During a drug-induced QT-interval prolongation Izumi et al.²⁷ found that with a large apicobasal and anterolateral dispersion of ventricular repolarization, the interval between the peak and the end of the T wave (Tp-e) in the limb leads expresses spatial (total) distribution of repolarization in the whole LV. the terminal part of the QT interval (T peak to T end; Tp-e) and in particular the heart rate corrected Tp-e (cTp-e) were found to be strong predictors of mortality during the first year post-AMI.²⁸ The predictive value of beat-to-beat QT variability index (QTVI) in heart failure patients across the continuum of LV dysfunction was found to predict only cardiovascular mortality and non-SCD, but not SCD nor extra cardiac mortality. Abnormally augmented QTVI separates 97.5% of healthy individuals from heart failure patients at risk.²⁹

T-wave morphology (normal, biphasic, inverted, bifid, or combined patterns) were scrutinized by Hekkala et al.³⁰ after low-dose epinephrine injection dissimilar T-wave patterns were noted between controls and silent LQTS mutation carriers.

In over 19,000 subjects who underwent cardiac catheterization and had ≥ 1 native coronary artery stenosis $\geq 75\%$, automated QTc measurements were obtained from a baseline ECG.³¹ black race and female gender were independently associated with a prolonged QTc, after adjustment for cardiac risk factors. Women, but not men, were found to have prolonged QT interval if depressed after an acute coronary syndrome.³²

To increase QTc data accuracy, Malik et al.³³ used subject-specific QT/RR curvatures and suggested to consider this in the optimization of subject-specific heart rate corrections.

Malignant Arrhythmias

Yokokawa et al.³⁴ used automated analysis of the 12-lead ECG and could identify the exit site in most patients with postinfarction ventricular tachycardia. Even in the absence of structural heart disease an increased prevalence of J-wave syndrome was found among patients with idiopathic VF.³⁵ A 5-year follow up of initially symptomatic patients with Wolf-Parkinson-White syndrome demonstrated that short accessory-pathway effective refractory period and antioven-tricular reentrant tachycardia triggering sustained

preexcited atrial fibrillation were independent predictors of malignant arrhythmias,³⁶ although to reach statistical significance, soft end point, like "presyncope" were also added.

The Use of Holter Technology

Specific, less favorable indices of heart rate variability (HRV) in both older and young adults were found by Soares-Miranda et al.³⁷ on 24-hour Holters or repeated 5-minute ECGs in persons with trans-fatty acid-18:2 consumption, but not with trans-18:1; the former but not the latter in red blood cell membranes has been shown to be associated with sudden cardiac arrest. The authors stressed the need to investigate potential HRV-related mechanisms, whereby trans-18:2 may increase arrhythmic risk.

Abe et al.³⁸ found that late potential (LP) characteristics detected by the Holter-based signal-averaged ECG system over 24 hours differ between BS and arrhythmogenic right ventricular cardiomyopathy (ARVC) patients, as dynamic daily variations of LPs were seen only in BS patients. This may imply that mechanisms of lethal ventricular arrhythmia in BS may be more correlated with autonomic abnormality than that of ARVC.

In patients with chronic heart failure average TWA in ambulatory Holter recordings was a predictor of SCD, after a median follow-up of 48 months, of SCD.³⁹ Microvolt TWA was assessed by Mollo et al.⁴⁰ by the modified moving average method, considering all 12 ECG leads (TWA_tot) or 6 ECG precordial leads only (TWA_prec): in healthy people by both methods TWA was ≤ 75 and $\leq 65 \mu\text{V}$, respectively, in 95% of subject: in IHD patients TWA values were higher compared with healthy individuals. Dr. Madias, commenting on these results suggested that TWA testing can be more reliable in predicting SCD when the confounding rule of T-wave amplitude are considered and investigated.

Repolarization abnormalities, leading to a potential risk for life-threatening arrhythmias were demonstrated on Holter ECGs in patients with vasospastic angina during asymptomatic periods.⁴¹ Maury et al.⁴² reported of spontaneous VF by the use of a loop recorder, implanted for syncope associated with ER pattern in the inferior leads.

The usefulness of continuous ECG monitoring for symptomless atrial fibrillation was validated

by a consensus team headed by Camm et al., the recent and promising technology for continuous monitoring adds relevant information for detecting and treating rhythm and rate disturbances.⁴³

MISCELLANEOUS

Patients with diabetes mellitus (DM) and metabolic syndrome (MetS) displayed significant changes in QRS complex that suggest depolarization sequence deterioration. Similar changes were observed also in the offspring of patients with DM and MetS, which suggests early subclinical cardiovascular damage.⁴⁴ A consensus report on P-wave abnormalities concluded that the interatrial blocks, that is, the presence of delay of conduction between the right and left atria, are the most frequent atrial blocks. P-wave duration of ≥ 120 ms, longer P waves with biphasic morphology in inferior leads and the transient appearance of these parameters in the same ECG recording are classified as first, third, and second interatrial blocks, respectively. The first degree interatrial blocks are common and are related to atrial fibrillation and an increased risk for global and cardiovascular mortality, while the third degree is much less frequent, but is a strong marker of left atrial enlargement and paroxysmal supraventricular tachyarrhythmias.⁴⁵

Platonov et al.⁴⁶ estimated atrial fibrillatory rate using spatiotemporal QRST cancellation and time-frequency analysis and followed their patients with mild to moderate heart failure for a median of 44 months, with primary end point defined as total mortality and secondary end points as sudden death and heart failure death. Reduced atrial fibrillatory rate was associated with increased risk of death from heart failure progression.

In patients referred for exercise echocardiography an increased T-peak to T-end (TpTe) interval, representing transmural dispersion of repolarization, was found to be associated with echocardiographic markers of diastolic dysfunction, both at rest and when induced by exercise.⁴⁷

Over 3000 patients were prospectively followed for a median of 9.9 years by Hartaigh et al.⁴⁸: patients with a resting heart rate of ≥ 84 had a reduced survival time for overall and cardiovascular mortality and had a significantly elevated adjusted risk for total and cardiovascular mortality.

Porela et al.⁴⁹ demonstrated that the PR segment depression in any lead had a high sensitivity (88.2%) but fairly low specificity (78.3%) for myopericarditis. The most favorable predictive power to differentiate myopericarditis from STEMI (positive 96.7% and negative power 90%) was the combination of PR depressions in both precordial and limb leads.

In a study Rautaharju et al.⁵⁰ isolated negative T waves were independent predictors of mortality, even in man with no evidence of heart disease.

ST level in lead aVR was measured in the HERO-2 trial: ST elevation ≥ 1 mm was associated with higher 30-day mortality for both inferior and anterior infarction. Deeper ST depression (0, 0.5, 1, and ≥ 1.5 mm) was associated with higher mortality for anterior infarction but not for inferior infarction.⁵¹

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