SPECIAL REPORT

The Year of 2008 in Electrocardiology

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As in past years,^{1–3} my editor assigned to me again the important task to choose the articles that I judge had the greatest impact on our understanding and clinical use of electrocardiology during 2008. The limit of 50 papers chronicled, set during previous years, is strictly being kept also now, even though this carries the difficulty of omitting many important and worthy publications.

ISCHEMIA DETECTION AND EVALUATION

While conspicuous ST-T alterations were and are clear indications for myocardial ischemia, whether acute, subacute, chronic or latent, minor and not readily recognizable abnormalities of this segment of the ECG are poorly understood and only rarely investigated. The prognostic significance in older adults of such isolated minor nonspecific ST-segment and T-wave abnormalities was demonstrated by Kumar and coworkers.⁴ ST-segment depression or T-wave flattening or inversion <1.0 mm was significantly associated with risk for all cause mortality but not with nonfatal myocardial infarction, suggesting that they may in part represent arrhythmogenic substrate.

Another previously considered innocent finding among healthy young individuals, the J-point ST elevation ("early repolarization" pattern) in the inferior or lateral leads was found to be present more frequently in the ECG's of patients with idiopathic ventricular fibrillation than among healthy control subjects and may thus become a marker of this life-threatening condition.⁵

The use of body surface maps improved the detection of ST-elevation in the high right anterior, posterior, and right ventricular territories and acute myocardial infarction in the presence of left bundle branch block.⁶ New ECG criteria for lateral myocardial infarction (R/S ratio in $V_1 \geq 0.5$ and R amplitude in $V_1 > 3$ mm) present very high specificity and lower but very acceptable sensitivity for lateral myocardial infarction; new criteria based on R waves in V_2 or T waves in V_1 to V_2 do not discriminate between inferior and lateral myocardial infarction.⁷

HEART RATE DYNAMICS

Among the various methods and techniques used for the determination of nonlinear multifractal heart rate dynamics, 5-hour daytime and nighttime subsets were analyzed by Galaska and coworkers;⁸ the authors found that the multifractal fluctuation analysis method is superior to the wavelet transform modulus maxima method for studying multifractal properties of the heart rate both in healthy subjects and patients with left ventricular systolic dysfunction.

HEART RHYTHM DISTURBANCES

Differences among African-American, Chinese, Hispanic, and non-Hispanic white men and women were demonstrated in the Multiethnic Study of Atherosclerosis (MESA);⁹ the authors pointed out a possible association between these findings and

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the ethnic differences in inherited arrhythmia syndromes and in sudden death.

Racial differences were demonstrated also in the study of Magalski and coworkers.¹⁰ Among highly trained American football players, the black athletes had significantly more abnormal ECG patterns, compared with their white counterparts, the most common being increased precordial voltages and diffuse T-wave inversions. Black athletes with left ventricular hypertrophy had a higher prevalence of ST-segment elevations and deep T-wave inversions.¹¹

P-wave dispersion in standard twelve-lead ECG was found to be a good predictor of transition from paroxysmal to persistent atrial fibrillation.¹² Analysis of P-wave morphology derived from P wave signal averaged ECG without the commonly applied bandpass filtering, was shown to enable the identification of the interatrial conduction route with high accuracy.¹³ The criteria of frontal plane F waves was found to be the best diagnostic criteria for atrial flutter on the surface ECG.¹⁴

Several investigations shed light on the anatomical locations of ventricular arrhythmias: ventricular tachycardia originating from the posterior papillary muscle in the left ventricle could be diagnosed according to a right bundle-branch block and superior-axis QRS morphology during the tachycardia or ventricular premature complexes.¹⁵ Ventricular arrhythmias originating from the junction of the left and right coronary sinuses of Val-salva in the aorta are characterized by a QRS pattern in leads V₁-V₃.¹⁶ Ischemic ventricular fibrillation in ST elevation myocardial infarction could be related to the culprit artery being the right coronary and left circumflex arteries; in these patients a longer PR and QRS intervals were found and intramural slowed conduction was proposed to be a substrate to the ventricular fibrillation.¹⁷

ECG FOR DEVICE THERAPIES

The importance of optimal left ventricular lead position was stressed by Ypenburg and coworkers in obtaining benefits from cardiac resynchronization therapy (CRT).¹⁸ Patients with RBBB undergoing CRT had low rates of symptomatic and echocardiographic response, and their survival free from orthotopic heart transplantation or ventricular assist device placement was significantly worse than in patients with LBBB.¹⁹

Microvolt T-wave alternans (MTWA) classification did not predict the risk of ventricular tachyarrhythmic events in ICD treated patients, although total mortality was significantly increased if MTWA was positive.²⁰ In contrast to previous studies MTWA was not useful as an aid in clinical decision making on implantable cardioverter defibrillator therapy among patients with heart failure and left ventricular systolic dysfunction.²¹

Wider QRS after CRT device implantation was found to be an independent predictor of mortality or transplantation.²²

ECG SIGNS IN SPECIFIC DIAGNOSES AND CONDITIONS

Induced hypoglycemia in healthy subjects was associated with a significantly decreased PR interval and T-wave amplitude and area and increased QTc interval, alterations that may be of importance in provoking severe arrhythmia in diabetic patients.²³

Severe hypothermia induced classical Brugada-like ECG changes, disappearing after rewarming to a normal body temperature, was observed by Bonnemeier and coworkers.²⁴

In a small (n = 14) number of patients with Wolff-Parkinson-White (W-P-W) Syndrome, ECG imaging, a novel modality for noninvasive electroanatomic mapping of epicardial activation and repolarization,²⁵ could localize ventricular insertion sites of accessory pathways to guide ablation and evaluate its outcome in pediatric patients with W-P-W. Following successful ablation the abnormal repolarization gradients resolve over a period of 1 month after a return to normal sinus rhythm, a time course consistent with long-term cardiac memory. Commenting on this article, Dr. Robert L. Lux* stated that although we are far from having definitive or reliable noninvasive methods for assessing arrhythmogenic risk, we are "much closer than we were" to having noninvasive tools to assess the electrophysiology of the heart.

An exceptionally narrow QRS complex (prevalence of 0.8% in a large database) an inverse relation was found between QRS duration and heart rate.²⁶ Hayat and coworkers investigated the

* Lux RL. Noninvasive assessment of cardiac electrophysiology for predicting arrhythmogenic risk. Are we getting closer? *Circulation*. 2008;118:899-900.

cardiac effects of left bundle-branch block (LBBB) using myocardial contrast echocardiography and demonstrated that myocardial blood flow is preserved while myocardial blood flow reserve is reduced in LBBB patients with left-ventricular systolic dysfunction.²⁷

A decreased heart rate variability even after controlling for traditional risk factors, was associated with increased C-reactive protein and interleukin-6, suggesting that autonomic dysregulation may lead to inflammation.²⁸

Scrutinizing the ECG findings in 59 female patients with stress (takotsubo) cardiomyopathy showed in 56% of the patients anterior ST-elevation, with magnitudes less than in controls with left anterior descending coronary artery occlusions; in other patients without ST-elevation, the ECG revealed diffuse T-wave inversion, healed anterior infarctions or nonspecific changes; in 8.5% the ECG was normal.²⁹

THE BRUGADA SYNDROME (BS)

Several outstanding investigations were published during 2008 highlighting the importance of the BS. Fragmented QRS was found to be a substrate for spontaneous fibrillation in patients with BS and predicted a high risk of syncope in these patients.³⁰ The same group of investigators supported evidence that the negative T wave associated with Type-1 BS is due to a preferential prolongation of repolarization in the epicardium compared with that in the endocardium.³¹ A study by Kusano and coworkers³² examined the relationships of atrial fibrillation with genetic, clinical and electrophysiological backgrounds in BS and showed that spontaneous AF, occurring mostly at night, and atrial vulnerability are important predictors of VF events that cause sudden cardiac death. As the vagal tone is higher at night than during the day, the circadian increase of the sympathetic tone during the day may help to prevent arrhythmias.

QT INTERVAL ABNORMALITIES

In patients with short QT syndrome (SQTS), which carries a high risk of sudden cardiac death, Anttonen and coworkers³³ measured the T-wave peak to T-wave end interval (TPE) and found an increased diurnal average of TPE/QT ratio, as compared to controlled subjects, showing an increased transmural dispersion of repolarization, explaining

possibly the increased vulnerability to ventricular arrhythmias of these patients. Electrocardiographic and echocardiographic correlations³⁴ showed that the inscription of the U wave in SQTS patients coincided with aortic valve closure and isovolumic relaxation, supporting the hypothesis that the U wave is related to mechanical stretch. Altered ventricular stretch and induction of altered contractile patterns and altered ventricular stretch were demonstrated to contribute to the initiation of cardiac memory.³⁵

Studying a single family with SQTS, Maison-Blanche and coworkers³⁶ demonstrated that the universal correction-formulas consistently provided higher values of corrected QT interval duration at the mean Holter heart rate than a subject-specific correction formula; the authors suggested that this formula may provide a better cutoff value definition for the diagnosis of SQTS.

Jeyaraj and coworkers³⁷ used erythromycin, an I_{Kr} blocker, to unmask occult congenital long QT syndrome and this together with the sensitive repolarization measure T peak-to-end interval in LQT2 patients. Short-term beat-to-beat variability of QT intervals was found to be increased in patients with drug-induced long-QT syndrome and was suggested to use for the identification of patients at risk for potentially life-threatening arrhythmias.³⁸ Mine and coworkers³⁹ demonstrated that beat-to-beat QT interval variability is affected by drugs that modulate the autonomic nervous system. These findings indicated that the parasympathetic system may act preferentially on the QT interval itself while the sympathetic system appears to affect QT interval variability.

PREDICTION OF PROGNOSIS

Although British investigators found a limited incremental value of the resting ECG in ambulatory patients with suspected angina, increased somewhat by adding exercise ECG data,⁴⁰ several other recent investigators demonstrated prognostic value of various ECG parameters.

The utility for mortality prediction and arrhythmic risk evaluation of microvolt T-wave alternans was demonstrated in ischemic cardiomyopathy.⁴¹ In nonischemic cardiomyopathy a planar QTS-T angle >90° was found to have important prognostic value.⁴² In this disease a blunted baroreflex activity was a significant predictor of arrhythmic events but heart rate variability and turbulence did not yield predictive power in their patients.⁴³

The predictive value of various heart rate parameters during exercise tests⁴⁴ and of ventricular conduction blocks and left anterior hemiblock⁴⁵ were also reconfirmed recently.

In patients after myocardial infarction ST-segment elevation in anterior leads was a significant predictor of events in women, whereas ST depression in lateral leads was a significant predictor in men.⁴⁶ A fragmented wide QRS was found to be a sign of myocardial scar and an independent predictor of mortality in the investigation of Das and coworkers⁴⁷ QRS fragmentation in patients with arrhythmogenic right ventricular dysplasia was shown to have a high diagnostic value similar to epsilon potentials by a highly amplified and modified recording technique.⁴⁸

The simple visual criterion of an upward pointing T wave in aVR in males was associated with an annual cardiovascular mortality of 3.4% and the risk of five times.⁴⁹ ECG signs of left atrial abnormality, i.e., a prolonged P-wave duration or positive P-wave terminal force in lead V₁, if coupled with echocardiographic left atrial abnormalities, increased the predictive value for recurrence of heart failure and mortality, compared to the predictive value of this last test alone.⁵⁰ Abnormal heart rate turbulence was documented as a strong predictor of total mortality and sudden death in congestive heart failure.⁵¹ In cardiac patients with sinus arrhythmia of nonrespiratory origin ("erratic sinus rhythm") in the Cardiac Arrhythmia Suppression Trial (CAST) in these patients an increased mortality was demonstrated.⁵² Abnormal heart rate recovery and chronotropic response to exercise identified patients with higher rates of all-cause mortality or nonfatal myocardial infarction and provided additional risk stratification among patients who were low-risk according to the Duke Treadmill Score.⁵³

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