

Electrocardiogram Still the Cardiologist's Best Friend

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Case presentation: A 22-year-old male, previously healthy, came to the outpatient clinic soon after an episode that he described as "near fainting" during complete rest, but at the time he was feeling strong anger because of a dispute with his friends. The physical examination was normal, but the resting 12-lead ECG, taken for the first time in his life, showed alterations diagnosed as Brugada syndrome (Figure). Holter monitoring showed the typical signs of the syndrome with no other abnormalities. The patient was referred for further evaluation, including family search for this syndrome, which turned out negative. Currently, implantation of an implantable cardioverter-defibrillator is being considered in a tertiary hospital for this patient.

Background

In the last several years, we have seen a new surge of interest in electrocardiology.¹ In the following report, we describe innovations in interpreting the 12-lead ECG in the physician's office that contribute to an instant diagnosis and to practical conclusions in our day-to-day clinical practice.

Patients at High Risk for Sudden Cardiac Death

Although >90% of cases of sudden cardiac death (SCD) occurs in persons without known or previously recognized structural or functional cardiac abnormalities, scrutinizing the QRS voltage, as well as the QT and corrected QT (QTc) intervals of the surface ECG, will help in diagnosing risk factors for SCD. A QTc >450 ms for men and >470 ms for women was an independent risk factor for SCD in subjects enrolled in the Rotterdam Study aged ≥ 55 years; a 3-fold increased risk of SCD after adjustment for other risk factors was found in these patients.² An increased QRS voltage was found to increase the risk for out-of-hospital cardiac arrest in women but not in men in the Reykjavik Study.³ In patients in whom coronary artery disease is suspected, the presence of isolated left anterior hemiblock represents an increased risk for arrhythmic cardiac death.⁴

Patients Resuscitated From Cardiac Arrest

Patients resuscitated from cardiac arrest due to ventricular tachyarrhythmia without clear precipitating factors are at high risk of recurrence, and therefore long-term prophylactic therapy is indicated.

Wever and Robles de Medina⁵ pointed out that in contrast to older beliefs, survivors of idiopathic ventricular fibrillation are currently also considered high-risk patients, because the recurrence rate of life-threatening episodes was as high as 43% after an average of >6 years of follow-up.

Wolff-Parkinson-White Syndrome

Wolff-Parkinson-White syndrome in many cases shows preexcitation on the surface ECG. These patients have a risk of SCD <1 per 1000 patient-years of follow-up. Almost all survivors of SCD with Wolff-Parkinson-White syndrome have had symptomatic arrhythmias before the event, but up to 10% experience SCD as their first manifestation of the disease.⁶

Arrhythmogenic Right Ventricular Dysplasia

The diagnostic ECG marker for arrhythmogenic right ventricular dysplasia is, in the absence of right bundle-branch block, an S-wave upstroke ≥ 55 ms in V₁ through V₃, which correlates well with disease severity and subsequent induction of ventricular tachycardia on electrophysiological study.⁷ These patients have spontaneously abnormal ECGs in 83.9% of

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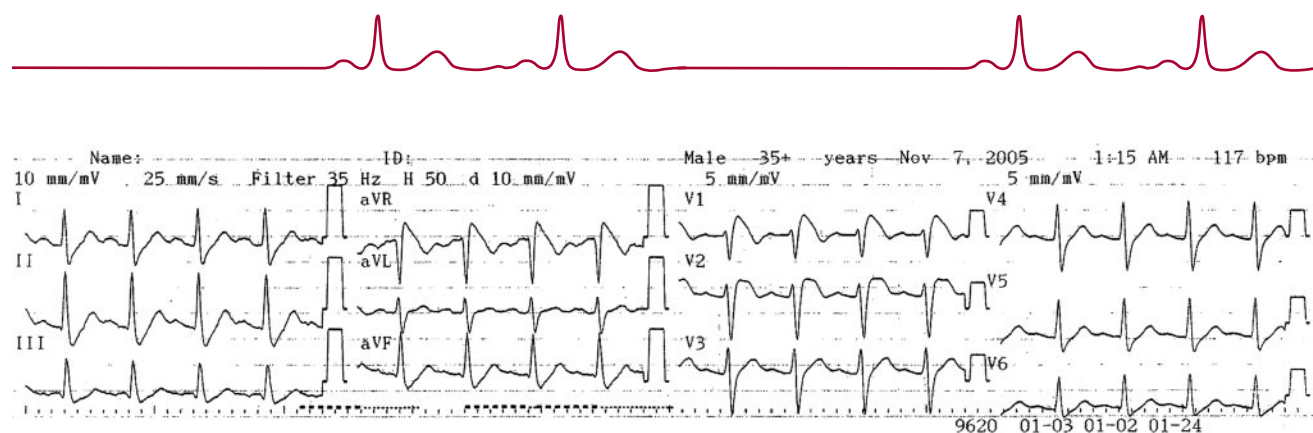
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Twelve-lead ECG of the patient showing typical changes for Brugada syndrome.

cases.⁸ The authors studied 130 patients with a mean follow-up of 8.1 years, during which 24 deaths were recorded. All patients who died had a history of ventricular tachycardia. Multivariate analysis showed that after adjustment for gender, history of syncope, chest pain, inaugural ventricular tachycardia, recurrence of ventricular tachycardia, and QRS dispersion, clinical signs of right ventricular failure and left ventricular dysfunction both remained independently associated with mortality. The syndrome is progressive, and within 6 years of presentation, nearly all patients had an abnormal finding on their surface ECG.

Prolonged QTc Interval

A prolonged QTc interval was associated with an increased risk of coronary heart disease and cardiac mortality in both black and white healthy men and women.⁹ A prolonged QTc was associated in the Atherosclerosis Risk In Communities (ARIC) Study with the presence of ECG abnormalities, possibly resulting from small, silent myocardial infarctions. These authors viewed a prolonged QTc as a marker of subclinical atherosclerosis. Two thirds of the cases of SCD were associated with an abnormal prolongation of the QTc interval. This investigation showed that in individuals with borderline and abnormally prolonged QTc duration, a dose-response effect existed between the duration of the QTc interval and the risk of SCD in the age groups of 55 to 68 years and >68 years, separately for men and women, after adjustments for relevant covariates. In view of knowledge about the

QT-prolonging properties of various important antiarrhythmic drugs and given that the administration of several of these drugs is associated with an increased mortality,¹⁰ meticulous clinical and ECG follow-up of such patients is mandatory.

Short QTc Interval

A short QTc interval, ≤ 300 ms, diagnosed on the 12-lead ECG became a relatively new clinical entity called the "short-QT syndrome," characterized by the absence of structural heart disease, a family history of SCD, and major or minor arrhythmic events.¹¹ This syndrome was shown to be a familial cause of sudden death, and the importance of recognizing this ECG pattern even in young, otherwise healthy subjects was stressed by Gaita and coworkers.¹²

Brugada Syndrome

The Brugada syndrome, an arrhythmogenic disorder associated with a high risk of SCD due to ventricular tachycardia/fibrillation, is diagnosed on the 12-lead ECG by a pattern of right bundle-branch block and a coved, ≥ 2 -mm ST-segment elevation in leads V₁ through V₃. In patients with Brugada-type ECG and no history of cardiac arrest, among 12 noninvasive risk indices in multivariate analysis, spontaneous changes in the ST segment were found to be the most significant predictor of subsequent sudden death or ventricular tachyarrhythmia during a 40 ± 19 -month follow-up.¹³ However, because ST-segment elevation is associated with a wide variety of benign and malignant pathophysio-

logical conditions, a differential diagnosis is difficult at times.¹⁴

Noncardiac Surgery Candidates

Noncardiac surgery candidates with coronary artery disease need preoperative evaluation, which should certainly include a 12-lead ECG. The prognostic information available from an ECG was studied by Jeger and coworkers.¹⁵ After adjustment for clinical baseline findings, ST depression and faster heart rates were independent predictors of all-cause mortality. Faster heart rate was also an independent predictor of major adverse cardiac events at 2 years. The predictive value of the ECG was independent of clinical findings and perioperative ischemia.

Asymptomatic Individuals

When asymptomatic individuals, such as those included in the Copenhagen City Heart Study,¹⁶ presented with left ventricular hypertrophy with ST depression and negative T waves in their ECG, they had an age-adjusted relative risk of 3.78 for myocardial infarction, 4.27 for ischemic heart disease, and 3.75 for cardiovascular disease during a 7-year follow-up. Given these results, our European colleagues concluded that in asymptomatic individuals, ECG findings should be treated "on an equal footing" with the classic risk factors and can be involved in risk assessment.¹⁷

Female Patients

In female patients, the value of the ECG for risk stratification was similar

to that in males, in contrast to the widespread misconception that the ECG is of limited utility in women.¹⁸ Rautaharju and coworkers¹⁹ studied 5 ECG variables in men and women and found them to be equally significant mortality predictors in both genders.

Unrecognized Myocardial Infarction

Unrecognized myocardial infarction in men carries a substantially increased coronary risk, and its diagnosis in the office is therefore of high importance. The determination of optimal ECG criteria for this retrospective diagnosis was the subject of several studies. Ammar and coworkers²⁰ scrutinized 6 different surveys and described a high specificity for ECG criteria (91.9% to 97.5%) in all studies but a low sensitivity (20.8% to 29.7%); even the British Regional Heart Study²¹ provided a sensitivity of only 37%. In this last study, a somewhat better prognosis was found for men with unrecognized infarctions than for those with recognized infarctions: Adjusted to an average age of 50 years, the percentage of men surviving for 15 years free of a new major cardiovascular event was 52% for the former and 44% for the latter group.

Post-Myocardial Infarction Patients

After reperfusion/revascularization therapy, post-myocardial infarction patients who had a prolonged QRS duration (≥ 120 ms) showed on multivariable analysis the highest association with total mortality (hazard ratio 4.0, 95% confidence interval 2.3 to 6.9).²² The association of prolonged QRS duration and late mortality was particularly strong in patients with left ventricular ejection fraction $\leq 30\%$.

Cardiac Resynchronization Therapy

Optimal candidates for CRT are the patients with a QRS complex duration >120 ms, dilated cardiomyopathy on an ischemic or nonischemic basis, left ventricular ejection fraction ≤ 0.35 ,

New York Heart Association functional class III or IV despite maximal medical therapy for heart failure, and sinus rhythm.²³ Even the success of cardiac resynchronization therapy can be evaluated by measuring the QRS complex. Among multiple demographic, clinical, and ECG variables, the amount of QRS shortening associated with biventricular simulation was the only independent predictor of a good clinical response, as demonstrated by Lecoq and coworkers.²⁴

Heart Failure

HF is frequently associated with a prolongation of the QRS complex beyond 120 ms, an abnormality observed in 14% to 47% of the patients in the study by Kashani and Barold.²⁵ Left-sided intraventricular conduction delay predisposed patients to an increased risk of tachyarrhythmias and was associated with more advanced myocardial disease, worse left ventricular function, poorer prognosis, and a higher all-cause mortality rate. A graded increase in mortality was observed with the width of the QRS complex, and a QRS <120 ms, QRS 120 to 160 ms, and QRS >160 ms correlated with 20%, 36%, and 58% mortality, respectively, at 36 months.²⁶ The mean QRS complex amplitudes and the sum of all QRS complex amplitudes were found to be "unique" for predicting the result of a positive versus negative dobutamine stress echocardiogram in patients with ischemic left ventricular dysfunction.²⁷

In patients with chronic HF, a QRS duration >140 ms was associated with a 60% event-free survival rate versus 90% among those with a QRS duration ≤ 144 ms. This ECG parameter was complementary to further echocardiographic assessment of these patients.²⁸

The ECG and β -type natriuretic peptide were evaluated as screening tools for left ventricular systolic dysfunction in a random elderly population.²⁹ For ECG alone, sensitivity, specificity, and negative and positive predictive values to detect left ventric-

ular systolic dysfunction were 96%, 79%, 100%, and 26%, respectively.

Hypertensive Patients

In hypertensive patients, a strain pattern, defined as a down-sloping convex ST segment with inverted asymmetrical T-wave opposite the QRS axis in lead V₅ or V₆, identified an increased risk of developing HF and of dying as a result of HF. This was found even in the setting of aggressive blood pressure lowering, which suggests that more aggressive therapy may be warranted in hypertensive patients with ECG strain to reduce the risk of HF and HF mortality.³⁰ ECG follow-up in patients with ECG evidence of left ventricular hypertrophy showed that a reduction in the left ventricular hypertrophy criteria, using the Cornell voltage-duration product and/or Sokolow-Lyon criteria, was associated with a reduced likelihood of cardiovascular events.³¹

Conclusions

The 12-lead surface ECG can indicate pathological changes even before structural changes in the heart can be diagnosed by other methods. The recording of an ECG was of great value for several past generations of cardiologists and continues to provide vital information. Researchers should further scrutinize Einthoven's ingenious method, and clinicians should continue to tap this important and reliable source of information.

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Disclosures

None.

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