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Electrocardiographic Markers of Increased Risk for Cardiac Events Including Sudden Cardiac Death A Commentary on the QRST Angles

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Abstract

Cardiovascular disease is one of the major causes of morbidity and mortality in many countries in the world. Cardiac disease might present as electrical and/or mechanical dysfunction, i.e. conduction system disorders and arrhythmias and/or reduced pump function or even overt heart failure. Electrocardiography based on body surface recordings can disclose the presence of cardiac disease. The QRS-T angle, which is the angle between the major forces of electrical activation and recovery of the cardiac chambers, has a scientifically proven value in the prognosis of cardiovascular events including sudden and non-sudden cardiac death. Evaluation of the QRS-T angle has, however, not yet been implemented in the clinical routine for the purpose of risk assessment. This is an invited commentary to an article on the QRS-T angle describing the methodology of its assessment and some of its major determinants including sex and diabetes with/without concomitant hypertension.

Keywords QRS-T angle; Cardiovascular risk assessment; Electrocardiography

Description

There are several markers of increased risk for cardiovascular events including but not limited to increasing age, male sex, Hypertension (HT), and Diabetes Mellitus (DM). These risk factors are, however, very broad and prevalent and, for obvious reasons, optimal treatment of HT and DM are the corner stones in the primary and secondary prevention of cardiovascular events associated with these conditions. Cardiovascular events include the development of coronary artery disease with angina and acute coronary syndromes (and revascularization therapies), the development of heart failure, and sudden cardiac death, but in a wider sense also stroke with or without precipitating atrial fibrillation. In order to reduce the risk for cardiovascular events, primary preventive measures need to be taken in high risk individuals among those categories mentioned in the first sentence. The problem is how to identify high risk individuals with a method which not only has a high-predictive accuracy but also can be applied to larger groups of people without procedure related risks and to a reasonable cost. And it is unfortunately unlikely that one single test of any kind would reflect the situation for the complex cardiovascular system and predict the risk of adverse events within a reasonable future. Present international risk scores are consequently based on more than one factor.

The heart is an electromechanical organ and cardiac dysfunction may manifest as electrical and/or mechanical abnormalities. It is therefore no surprise that electrocardiography plays an important role since more than a century and transthoracic echocardiography since more than half a century when it comes to the evaluation of cardiac function and risk evaluation. Electrocardiography is the fastest, most readily available and cheapest of the two. None of them are, however, included in the more general risk scores which are mainly focusing on the risk for coronary artery disease and its various manifestations. The present text is, however, an invited commentary on a publication by the author and co-workers on an electrocardiographic method that provide important prognostic information about cardiovascular events including sudden and un-sudden cardiac deaths, the assessment of the QRS-T angle [1].

During the last two decades abnormal QRS-T angles have become scientifically established risk factors for cardiovascular events [2-4], but their assessment has not yet been implemented in the clinical context for prognostic purposes. The QRS-T angle (or rather angles) reflects the relation between the major electrical forces during the activation (corresponding to the QRS complex) and recovery (represented by the T wave) of the cardiac chambers. The electrical activation or depolarization on the cellular level is very rapid (milliseconds), while it takes around 200-250 milliseconds complete repolarization. Electrical recovery therefore starts immediately after depolarization in the first activated parts (usually high on the left side of the ventricular septum) and goes on while the rest of the chambers are activated, i.e. during the QRS, and then during the ST segment and to the end of the T wave. This is the reason for why the entire QT interval from the QRS onset to the end of the T wave is measured to reflect ventricular repolarization; but the QT interval is another story.

The most typical example of a wide QRS-T angle is a Left Bundle Branch Block (LBBB) pattern with QRS and T wave discordance, i.e. they point in opposite directions with a typical negative QS and positive T in lead V1 and positive R and negative T in leads V4-6. In the presence of a LBBB-pattern on ECG, there is no need to measure the QRS-T angle to make a conclusion that some structural abnormality is likely present or will develop as a consequence of the mechanical dyssynchrony between the two chambers; a LBBB is a prognostically unfavorable sign. In the presence of a right bundle branch block combined with a left anterior or posterior fascicular block, the situation is similar. In our recent population based cohort study of almost 1100 participants 50-65 years old with similar proportions of women and men, the overall prevalence of abnormal

QRS-T angles was almost 7%. And 85% of cases were not explained by such bundle branch blocks and/or known structural heart disease. When comparing the prevalence in subgroups it was 2.5% in apparently healthy participants and around 20% in those with DM, while it was around 7% in those with HT and thus only slightly higher than in the entire group. Men had considerably wider QRS-T angles than women [1]. One important issue to be addressed in future research is therefore if intense multifactorial risk-factor management should be recommended specifically in people with DM and/or HT and abnormal QRS-T angles to reduce the risk for cardiovascular events. Notably, a study in patients with chronic renal failure showed that after renal transplant there was a regression of the QRS-T angle and signs of improved left ventricular structure and function [5].

Why is measurement of the QRS-T angles not an established tool in the clinical setting when risk assessment and a decision on intense primary prevention is a primary goal? There is more than one reason. One main reason is probably that neither the terminology nor the methodology is standardized. To begin with clarifying the terminology, there are three QRS-T angles appearing in the literature, two are called spatial because they are 3-dimensional, and one is called frontal because it is defined in the frontal plane. The latter is thus a projection of a spatial angle onto the frontal plane and consequently much less precise albeit relatively easy to measure. We concur we the Dutch group that the use of the frontal QRS-T angle is not to be recommended [6]. The spatial QRS-T angles are separated into the peak and mean QRS-T angles. The peak angle is defined as the angle between the maximum QRS- and T-vectors inscribed in the QRS- and T-vector loops, while the mean angle is defined from the QRS-area and T-area vectors. One step towards the implementation of the QRS-T angles was therefore a recent publication to explain, illustrate, and compare the peak and mean QRS-T angles. In short, they are similar and complementary rather than replaceable [1].

Secondly, the gold standard for recording and defining the peak and mean QRS-T angles is vectorcardiography (VCG) according to Frank [7,8]. VCG is very similar to ECG for the patient, but instead of 10 electrodes positioned 4 on the extremities and 6 on the chest as in the routine ECG, 8 electrodes are used and 5 positioned around the chest, one on the back of the neck, and two on the hips. This is not very different from recording of an ECG and does not pose a problem for a trained staff nurse or technician, according to our experience. The concepts regarding VCG were introduced in the 1930s and the method received certain popularity in the 1950s and early 1960s but then more or less lost general interest. In the 1960s special units for Coronary Care (CCU) were introduced, the focus was on the diagnose and treatment of patients with acute myocardial infarction, and the ECG turned out to be much more easy to interpret with regard to ST-elevation and the site of infarction. At that time many infarctions were unfortunately often large and involving the entire thickness of the ventricular wall or rather with a large endocardial involvement and diagnosed by the appearance of pathological q-waves. The vectorcardiographic QRS loop was much more difficult to interpret in this context and there was no or limited computer equipment to assist the recording and analysis of the VCG. The situation is very different today and a vectorcardiographic approach to electrocardiology has received increasing interest. One reason is the precise definition of the QRS-T angles and another are measures of global electrical heterogeneities (by electrophysiologists called dispersion) which can be obtained from the VCG but not from routine ECG. Due to limited access to VCG equipment, most of the research related to the QRS-T angles is presently, however, based on approximations from the routine ECG using customized software. When comparing the results of Frank VCG and ECG derived QRS-T angles on the individual level, there are unfortunately differences large enough to affect risk assessment (8 with comments in 1). So, we need ECG for many clinical purposes but VCG is preferable for other, and in the future both should be available for the benefit of our patients.

Before that goal can be reached other issues also need to be resolved. Automatic and reliable interpretation of VCG recordings must be available. In another recent publication we describe how that can be achieved [9]. In order to assist a busy clinician, the meaning of the acquired VCG measures needs also to be explained in real time; and there we are not yet. Like for a routine ECG, over reading of the interpretation and recommendation needs to be performed by the physician in charge before clinical decisions can be made. For that purpose some education is needed.

Conclusion

If this commentary can create some interest for the possibilities of an vectorcardiographic approach to electrocardiology, that might help in the ultimate goal to improve even further the care of our patients with already established or an impending risk for cardiovascular disorders.

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