Long QT syndrome, a purely electrical disease? Not anymore

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This editorial refers to ‘Left ventricular mechanical dispersion by tissue Doppler imaging: a novel approach for identifying high risk individuals with long QT syndrome’, by K.H. Haugaa et al. on page 330

The identification in 1995–1996 of the three major genes for the long QT syndrome (LQTS) has opened up the molecular era for arrhythmogenic disorders and has led to the frequent use of the term ‘channelopathies’ to define several diseases characterized by a high potential for life-threatening arrhythmias and by being caused by mutations on genes encoding ion channels involved in the control of the action potential.¹ Another concept, developed in parallel, was that of ‘primary electrical diseases’ which is now regularly applied to disorders such as LQTS, Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia, short QT syndrome, and others.²⁻⁵ ‘Primary electrical diseases’ soon became equivalent to ‘purely electrical diseases’ and the consensus still is that in these diseases there are no mechanical dysfunctions. As far as LQTS is concerned, the idea that this was a purely electrical disease in an otherwise completely normal heart has been around since the early days. When in 1991⁶ and 1994⁷ we attempted to challenge this concept, the cardiological community gave us the cold shoulder. Now, the tide may have turned.

Kristina Hermann Haugaa, with the group led by Jan Amlie in Oslo, reports an interesting study that evaluated myocardial contracture duration by tissue Doppler imaging (TDI) in 73 patients with genetically confirmed LQTS.⁸ The group included nine subjects affected by the Jervell and Lange-Nielsen (JLN) syndrome⁷,⁸ and 40 controls. Approximately half of the single mutation LQTS patients (RW-LQTS) and all JLN patients had a history of cardiac events (arrhythmias, syncope, or cardiac arrest). As expected, RW-LQTS patients had longer QT intervals compared with controls, and JLN patients had longer QT intervals compared with both controls and RW-LQTS patients. The duration of myocardial contraction was measured in the basal septal segment and defined as the time from the start of the R wave on ECG to the definitive zero-crossing of the decreasing velocity slope. The duration of contraction of the basal segment was assessed in all six traditional left ventricular wall positions and the standard deviation of these six values was calculated as an index of mechanical dispersion of contraction. A longer contraction duration was found between RW-LQTS patients and controls and, within LQTS patients, between those with and those without a previous cardiac event. Dispersion of contraction was also more pronounced in RW-LQTS patients with cardiac events compared with asymptomatic patients.

When we reported in 1991 the presence of an unsuspected abnormality in left ventricular contraction in 23 of 42 LQTS patients, we developed two quantitative indexes to quantify this phenomenon more efficiently.¹ The most evident abnormality was the presence of a very slow contraction phase before rapid relaxation that appeared either as a plateau or as a double-peaked contraction. Subsequently, calcium channel blockade by intravenous verapamil was shown to normalize completely even the most severe patterns of abnormality such as those with a double-peak morphology.⁵

Despite our pointing out that the contraction abnormality and, particularly, the double-peak morphology were the first clinical features found to be strongly associated with a history of syncope or cardiac arrest, these two reports were received with scepticism, more or less dismissed, and essentially ignored.

Seven years of silence passed until, in 1998, Nakayama, working in the group led by Tohru Ohe in Okayama, confirmed the presence of a phase of slow contraction (plateau) before rapid relaxation in patients with LQTS.⁷ They digitized two-dimensional short axis images performed at the basal and middle level of the left ventricle and reconstructed M mode echocardiograms in the corresponding 12 segments. They found that LQTS patients spent, on average, twice the amount of time in the plateau late systolic phase of contraction and that this plateau time, although abnormally prolonged in the whole left ventricle, was significantly more variable within the 12 analysed segments in LQTS patients

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compared with controls, suggesting the presence of a dispersion in the contraction abnormality. This good study apparently did not particularly impress the cardiological community which continued to ignore this aspect of LQTS.

In 2003, Savoye et al. first employed TDI to assess wall motion and myocardial velocities in LQTS. They compared 14 control subjects with 10 patients with ‘mild’ LQTS; their average QTc was 454 ms—not very prolonged. Myocardial velocities were measured in the basal and mid-segments of the septal, lateral, inferior, and anterior wall. They found results almost identical to ours. Not even this study, employing a novel and more powerful technique, has been able to shake the general view that LQTS is a purely electrical disease.

The present Norwegian study on a large group of genetically confirmed LQTS patients will hopefully force the cardiological community to accept the reality that LQTS is not a purely electrical disease. TDI has been validated as a method to quantify regional myocardial function as it allows more reliable regional measurements. While M mode echocardiography assessed radial wall thickness and movement, TDI, using apical views, assesses longitudinal myocardial velocities.

Once it has been established that the contraction abnormalities in LQTS patients do exist, the main practical question for the clinician is whether the contraction abnormality may contribute to a better risk assessment and what is the best way to quantify the abnormality for prognostic purposes. Current risk stratification in LQTS is largely based on previous cardiac events, on the degree of QTc prolongation, on gender, on genotype, and sometimes even on the specific mutation. While there is a definite increase in risk for values of QTc in excess of 500 ms, this notion does not help very much when dealing with the large number of patients with modest QTc prolongation. The study by Hermann Haugaa et al., while contributing to this important issue, unfortunately does not solve it.

Despite the claim in the title of the article that dispersion of left ventricular contraction identifies high-risk individuals, the predictive power shown refers to overall duration and not dispersion. Furthermore, no difference in dispersion was present between highly symptomatic JLN patients—who are at great risk for lethal events—and asymptomatic RW-LQTS patients. Therefore, the data suggest that overall contraction duration had better specificity but similar sensitivity for the identification of symptomatic LQTS patients compared with QTc. This modest superiority is likely to have been favoured by the fact that contraction duration was assessed with a retrospectively set cut-off point while QTc was assessed with a prospectively set cut-off point. Furthermore, while QT corrected for heart rate (QTc) was used, contraction duration was not corrected for heart rate, and symptomatic patients tended to have longer cycle lengths. A more appropriate comparison would have been between contraction duration and absolute QT interval duration. Alternatively, as we had originally proposed and performed for the duration of the abnormal plateau phase, the contraction duration could have been corrected for heart rate.

The choice to use overall contraction duration as a parameter of risk also appears questionable. Since the goal of the study was to increase the predictive accuracy of current risk stratification strategies, the fact that the prolongation of action potential duration is intrinsically related to a prolongation of contraction certainly limits the independent predictive power provided by this parameter, once the QT interval duration is accounted for. Furthermore, Hermann Haugaa et al. provide no hypothesis for a prolongation of all phases of myocardial contraction in LQTS patients. We had suggested that LQTS patients tended to have a faster contraction in the early phase, a finding that was then confirmed. The echocardiographic pattern and related biological signal that characterizes LQTS patients and particularly the symptomatic ones is, in all likelihood, the very slow contraction in the late systolic phase, leading in some cases to a secondary contraction before rapid relaxation and thus resulting in a double-peak morphology. Hermann Haugaa et al. describe in several patients the presence of marked secondary peaks of myocardial velocity after aortic valve closure (post-ejection velocity), a pattern that mimics the one just mentioned, but the authors do not provide any correlation between this finding and symptoms.

We had observed a strong correlation with severe cardiac events (syncope/cardiac arrest). We thought that this abnormal pattern might have been related to abnormal intracellular calcium handling with sustained or increased calcium concentration. These phenomena, in turn, could have been facilitated by early afterdepolarizations—a recognized cause of Torsades-de-Pointes in LQTS—not reaching threshold for the induction of arrhythmia, but causing an intracellular calcium increase. This hypothesis was reinforced by two findings. First, calcium channel blockade completely abolished the contraction abnormality in LQTS patients. Secondly, even a scarcely noticeable early afterdepolarization was shown to lead to a marked secondary intracellular calcium increase and consequent contraction in the isolated cardiomyocyte.

The study by Hermann Haugaa et al. is important. It provides, in an adequate number of patients, what should be considered the final evidence that a contraction abnormality is an integrant part of LQTS, which should no longer be regarded as a ‘purely electrical disease’. After almost 20 years it vindicates the validity of our original findings, thus showing that data carefully collected and carefully interpreted are eventually confirmed. This represents a rewarding and encouraging scientific message. Also the initial observation that this mechanical abnormality is more marked among symptomatic patients and has the potential to contribute to risk stratification has been confirmed. For this purpose, however, we believe that careful comparison of various echocardiographic measures is necessary to identify the single parameter that correlates best with symptoms and that may provide an independent contribution to risk stratification.

Conflict of interest: none declared.

References


