Inaccurate electrocardiographic interpretation of long QT: The majority of physicians cannot recognize a long QT when they see one

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BACKGROUND Physicians in all fields of medicine may encounter patients with long QT syndrome (LQTS). It is important to define the percentage of physicians capable of distinguishing QT intervals that are long from those that are normal because LQTS can be lethal when left untreated.

OBJECTIVES The purpose of this study was to define the percentage of physicians in the different disciplines of medicine who can recognize a long QT when they see one.

METHODS We presented the ECGs of two patients with LQTS and two healthy females to 902 physicians (25 world-renowned QT experts, 106 arrhythmia specialists, 329 cardiologists, and 442 noncardiologists) from 12 countries. They were asked to measure the QT, calculate the QTc (the QT interval corrected for the heart rate), and determine whether the QT is normal or prolonged.

RESULTS For patients with LQTS, 80% of arrhythmia experts but 50% of cardiologists and 40% of noncardiologists calculated the QTc correctly. Underestimation of the QTc of patients with LQTS and overestimation of the QTc of healthy patients were common. Interobserver agreement was excellent among QT experts, moderate among arrhythmia experts, and low among cardiologists and noncardiologists (kappa coefficient = 0.82, 0.44, and < 0.3, respectively). Correct classification of all QT intervals as either “long” or “normal” was achieved by 96% of QT experts and 62% of arrhythmia experts, but by only <25% of cardiologists and noncardiologists.

CONCLUSIONS Most physicians, including many cardiologists, cannot accurately calculate a QTc and cannot correctly identify a long QT.

KEYWORDS QT interval; long QT; electrocardiogram

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The long QT syndrome (LQTS) is a disease of myocardial ion channels that manifests clinically as recurrent syncope or cardiac arrest due to malignant ventricular arrhythmias. It may be caused by genetic mutations in the genes encoding these channels (congenital LQTS) or by medications or metabolic abnormalities that block the same channels (acquired LQTS). Prompt recognition is important because LQTS is associated with an increased risk for sudden death, yet treatment is highly effective for preventing arrhythmias.

Physicians in all fields of medicine may encounter patients with LQTS. For example, family doctors, internists, and pediatricians are likely to be the first to assess patients with congenital LQTS presenting with syncope. Neurologists may get referrals for such patients because the jerky movements observed at the time of arrhythmogenic syncope too often lead to a misdiagnosis of “epilepsy.” Also, the large list of medications that can cause a LQTS includes not only antiarrhythmic drugs, but also medications prescribed by gastroenterologists (like cisapride or droperidol), psychiatrists (like antipsychotic medications), and general practitioners (various antibiotics and antihistamines). Thus, physicians in all fields of medicine should be aware of this entity and should be able to recognize, or at least suspect, a LQTS. Since the hallmark of this disorder is a prolonged QT interval, the obvious first test for evaluating the likelihood that a LQTS is present involves assessment of the ECG to determine whether the QTc (the QT interval corrected for heart rate) is normal, borderline, or prolonged. We therefore conducted the present study to determine the percentage of physicians in different fields of medicine who can accurately measure the QT interval, calculate the QTc, and identify a long QT interval.

Methods

We presented four ECGs (traces of two patients with congenital LQTS and two healthy females) to 27 world-leading QT experts (arrhythmia specialists who have published clinical studies on the LQTS in peer-reviewed journals and are recognized for their clinical expertise). The range of QT and QTc values measured by the 25 QT experts who agreed to participate in this study were defined as “correct results.” We then presented the same ECGs to physicians from university hospitals in 12 countries (Australia, Austria, Brazil, Canada, China, England, France, Israel, Japan, Mexico, Paraguay, and the United States), and 877 agreed to participate in the study. These physicians were grouped as (1) arrhythmia specialists (106 cardiac electrophysiologists or cardiologists whose main activity is the treatment of cardiac arrhythmias); (2) cardiologists (n = 329); and (3) noncardiologists (442 physicians in all fields of internal medicine except cardiology). The last group consisted of internists (33%), neurologists (16%), pediatricians (15%), emergency medicine or intensive care specialists (18%), gastroenterologists (5%), and others (13%). All physicians were informed of the aim and nature of the study and remained unaware of the patients’ grouping. They were asked to study the four ECG traces, measure the QT interval, calculate the QTc, and determine whether the QT is normal, borderline, or prolonged. We then estimated the percentage of physicians in the three different categories (arrhythmia specialists, cardiologists, and noncardiologists) who measured the QT and calculated the QTc “correctly,” that is, whose results were within the range of values given by the QT experts.

Statistics

(1) The first analytic procedure was descriptive in nature and was applied to determine the percentage of correct answers in each group. (2) Modified kappa coefficients were calculated separately for each group as a measure of inter-rater agreement that takes into account the proportion of times that raters would agree by chance and correct for that proportion. Values above 0.8 are considered to have excellent agreement, whereas values below 0.4 are considered to have low agreement. (3) Comparing the distribution of answers among the different groups of physicians was done by calculating and drawing the best-fit model, using Prism software (Prism, GraphPad Software, San Diego). Analyses were done using SPSS software, version 12 (SPSS, Chicago). The kappa statistics were calculated using a published macro command for SPSS users, which can be found at ftp.spss.com/pub/spss/statistics/nichols/macros/mkappasc.txt, and were verified manually.

Results

Measuring QT and calculating QTc

The first two traces (Figure 1A, 1B) are from patients with congenital LQTS. All QT experts (except for one who defined the QT of patient B as “borderline”) defined the QT interval of both patients as prolonged, with a QTc ranging from 460 to 530 ms (patient A) and from 454 to 520 ms (patient B). Most physicians in the other three categories measured the QT interval correctly but erred when calculating the QTc (Figure 2A, 2B): 89% of arrhythmia experts, 84% of cardiologists, and 65% of noncardiologists entered a QT interval that was correct. However, whereas 80% of the arrhythmia experts also entered a QTc that was correct, less than 50% of cardiologists and less than 40% of non-cardiologists calculated the QTc correctly (Figure 2A, 2B).

Traces C and D (Figure 1C and 1D) are from healthy females. All QT experts identified both traces as normal, with a QTc ranging from 386 to 430 ms (trace C) and from 380 to 414 ms (trace D). The traces show physiologic U-waves. More than 80% of arrhythmia experts measured the QT of both traces correctly. Lower figures were achieved by cardiologists (76% for trace C and 61% for trace D) and by noncardiologists (63% for trace C and 57%
for trace D). Although 75% of the arrhythmia experts calculated the QTc of the first healthy patient correctly (Figure 2C), only 54% of them calculated the QTc of trace D correctly. Moreover, less than 40% of cardiologists and noncardiologists calculated the QTc of these healthy patients correctly (Figure 2C, 2D).

Interobserver agreement

For QTc calculations, interobserver agreement was excellent among QT experts (kappa coefficient = 0.82), moderate among arrhythmia experts (kappa = 0.44), and low for cardiologists and noncardiologists (kappa coefficient < 0.3 for both groups).

Comparing the distribution of answers

In Figure 3, the proportion of standard deviation to the mean is illustrated to enable comparison among groups with different actual mean values. For QT experts, the standard deviation was less than 5% of the mean (for all four ECGs) because most QTc values were closely concentrated around the mean. In contrast, for cardiologists and noncardiologists the standard deviation of QTc results was >12% of the mean because the QTc values entered scattered away from the mean. The dispersion of QTc results entered by arrhythmia experts is intermediate between the low dispersion of results achieved by QT experts and the wide dispersion among cardiologists and noncardiologists (Figure 3).

The best-fit curve is a graphic illustration of the distribution of QTc results by degree of specialty (Figure 4): (1) The distribution is larger for the less specialized groups. (2) The distribution lines for cardiologists and noncardiologists tend to merge, especially for the traces with long QT. (3) Cardiologists and noncardiologists frequently underestimated the QTc of patients with LQTS (top panels of Figure 4) but overestimated the QTc of the healthy patients (bottom panels of Figure 4). This error, which has more clinical significance than an error in the opposite direction (i.e., overestimation of QTc in patients with LQTS and underestimation of QTc in healthy individuals), can also be appreciated from Figure 2. For example, for patient A (with LQTS) 29% of cardiologists and 23% of noncardiologists entered a QTc that was too short, whereas only 3% of
cardiologists and 8% of noncardiologists entered a QTc that was too long. The opposite was true for the healthy patients. In trace D, 36% of cardiologists and 22% of noncardiologists entered a QTc that was too long, whereas only 14% of cardiologists and 17% of noncardiologists entered a QTc that was too short. Of note, 21% of cardiologists and 31% of noncardiologists entered a “do not know” answer (regarding estimation of QTc) for all traces (Figure 2).

Figure 2  Panels A–D denote the partition of results achieved by the physicians for ECGs A–D. White bars denote correct answers. Bars with horizontal lines denote answers that were incorrect because the QT (or QTc) values entered were too short. Bars with vertical lines denote QT (or QTc) values entered that were too long. Black bars denote “do not know” answers. AE = arrhythmia experts; C = cardiologists; NC = noncardiologists.

Figure 3  Results achieved by the physicians in the different categories for each one of the four ECGs. The results are presented as standard deviation divided by the mean. Smaller columns indicate that most of the results entered are closely concentrated around the mean. Taller columns indicate results scattered away from the mean.

Figure 4  Panels A–D denote the distribution of QTc results entered by the physicians for ECG traces A–D, respectively. The results are presented as best-fit curves for each physician’s category. Note that the curves of cardiologists and noncardiologists tend to overlap and that cardiologists and noncardiologists more frequently underestimated the QTc of patients with LQTS (more frequently entered QTc values that were too short; top panels) but also overestimated the QTc (more frequently entered QTc values that were too long) for healthy patients (bottom panels).
Discriminating between normal and long QT intervals

After measuring the QT and calculating the QTc, physicians were asked to categorize each trace as normal, borderline, or prolonged QT: 96% of QT experts and 74% of arrhythmia experts but only 35% of cardiologists and 31% of noncardiologists correctly identified the QT of both patients with LQTS as prolonged (Figure 5). Similarly, correct classification of both healthy patients as “normal QT” was achieved by 100% of QT experts and 80% of arrhythmia experts but only by 54% of cardiologists and 53% of noncardiologists. Finally, correct identification of all four traces (i.e., classification of traces A and B as long plus classification of traces C and D as normal) was achieved by 96% of QT experts, 62% of arrhythmia experts, and only 22% of cardiologists and 21% of noncardiologists.

Discussion

The LQTS can no longer be considered a medical curiosity. Advances in our understanding of the genetics and the pathophysiology of the LQTS as well as increased awareness by the medical community have led to increased recognition of the congenital form. Too often, however, there is a significant delay between the onset of symptoms and the eventual diagnosis. For example, the age at the onset of symptoms reported in the International LQTS Registry is 9 ± 6 years, whereas the age at diagnosis is 14 ± 10 years.7 This 5-year delay in diagnosis is inexcusable because highly effective therapy exists for this potentially lethal disorder.

Every physician encountering patients with palpitations, dizziness, syncope, or “seizures” should be alert to the possibility of a LQTS. Furthermore, because of the diverse spectrum of medications that may trigger LQTS,1,2,5 physicians in all fields of medicine should be able to recognize an iatrogenic LQTS. Consequently, the importance of being able to recognize a long QT interval cannot be overemphasized. Published studies reporting on the accurateness and reproducibility of QT measurements have focused on the performance of selected physicians with expertise in the field.8 In contrast, we evaluated the ability of a large number of physicians (from 12 different countries) to measure the QT interval, calculate the QTc, and decide whether it is normal or not.

Main findings

We found that physicians greatly differ, according to their field of expertise, in their ability to measure the QT interval correctly (Figure 2). The increasingly higher number of physicians who erred when measuring the QT interval, which can be seen as one moves from arrhythmia experts to cardiologists and noncardiologists (Figure 2), reflects how practice (or lack of it) affects the physicians’ ability to define where the T-wave (and consequently the QT interval) terminates. Physicians’ competence when estimating the QTc (the parameter used to distinguish normal from abnormal QT intervals) was even poorer (Figures 2). Less than 50% of cardiologists and 40% of noncardiologists calculated the QTc of patients with LQTS correctly, reflecting their limited knowledge about the formula for calculating the QTc or how to use it. Overestimating the QTc of a patient with LQTS or underestimating the QTc of a patient with normal QT would have limited clinical significance. Unfortunately, the opposite trend was observed. The most common error was underestimating the QTc of patients with long QT and overestimating the QTc of healthy patients. Finally, the ultimate decision as to whether a given QT interval is normal or prolonged was too often incorrect. Only 36% of cardiologists and 31% of noncardiologists recognized the QT of both patients with LQTS as prolonged, and less than 25% of cardiologists and noncardiologists categorized the QT intervals of all four patients (with and without LQTS) correctly.

Limitations

Only four ECGs were examined; the physicians’ performance could have been better (or worse) if more traces had been analyzed. Also, we do not know how many physicians declined to participate in the study. Thus, although the number of physicians interviewed was large (approaching 900 physicians in 12 countries), one may argue that our results do not reflect the competence of the physicians’ population at large. However, limited data from previous studies suggest that the limited knowledge of “QT matters” is indeed serious. First, in surveys involving 158 British doctors9 and 396 physicians from top-ranking university hospitals in the United States10 who were asked to measure
the QT interval of a simple ECG, correct measurements were made by only 24%\(^9\) and 43%\(^{10}\) of physicians, respectively. Second, large databases show that inappropriate prescription of medication combinations with potentially proarrhythmic QT-prolonging interactions is epidemic\(^{11}\) and continues despite appropriate Food and Drug Association warnings.\(^{12}\)

**Clinical implications**

Our study suggests that the majority of physicians in all fields of internal medicine, including many cardiologists and even some arrhythmia experts, cannot accurately calculate a QTc and cannot correctly identify a long QT when they see one. Efforts should be made at all levels of medical education to increase the awareness and the knowledge of the medical community about the LQTS. Until this is achieved, only arrhythmia specialists with special interest in the LQTS can be reliably trusted with QT measurements.

**References**