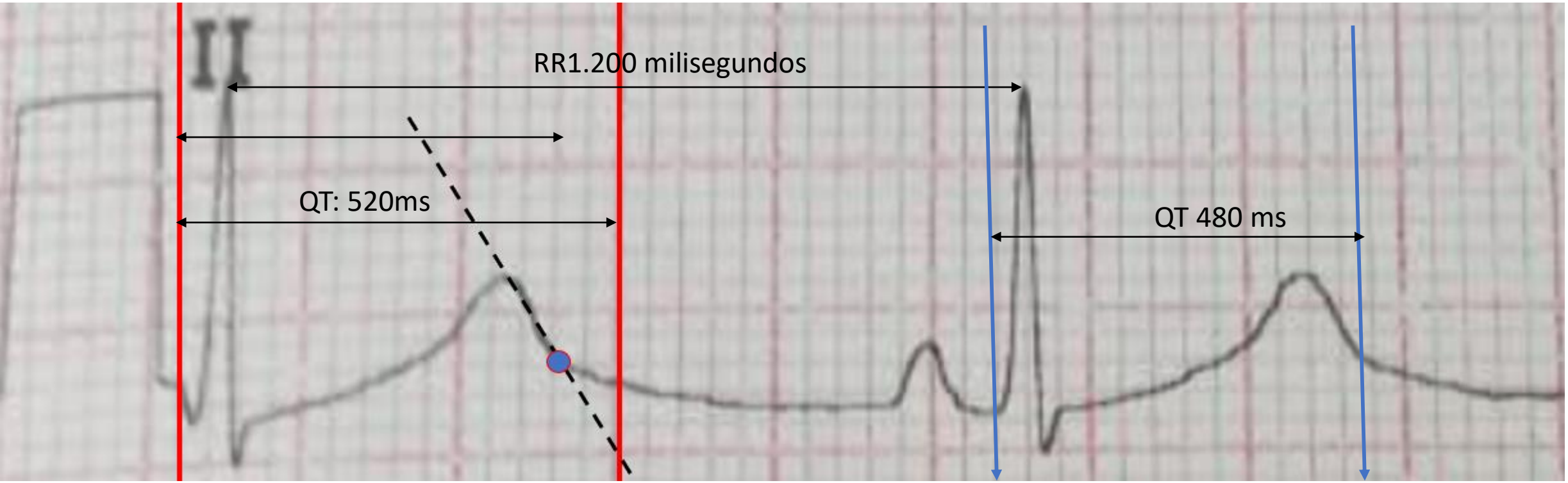
Queridos colegas: existen algunas carencias en este caso. Primero de todo el colega que presentó el caso menciona que fue rechazada para continuar sus actividades deportivas mas no menciona el porque. Es claro que todos focaron en si tenia o no interval QT/QTc prolongado. Sin saber cual fue el motivo. Otra cosa fundamental que deberiamos preguntar siendo una atleta profecional o de elite es si ella hacia uso por ejemplo de bebidas energéticas, lo cual es extremamente comun entre atletas de cualquier modalidad. Como mostramos en el email anterior el uso de bebidas energéticas prolonga el QT. En los casos dudosos como este yo empleo la medición del estudio de Framinghan. La medición del intervalo QT debe ajustarse a la frecuencia cardíaca(FC), lo que se denomina intervalo QTc. Esta corrección sirve para independizarlo de la FC de cada individuo y transformarlo en una medida de la actividad eléctrica comparable entre pacientes sanos y enfermos. Osea la duración del QTc es inversamente proporcional a la FC: a mayor FC menor duración y a maor FC menor QTc

Condiciones indispensables para medir el QT correctamente

1) **Jamás realizar el ECG en el período postprandial**
2) **Para iniciar el registro debemos dejar en cama en reposo > de 3 minutos porque para la adaptación se requiere este tiempo. Muchos técnicos (y médicos) no está alertados en este detalle y no esperan ese mínimo tiempo para iniciar la ejecución del trazado**
3) **La medición debe hacerse preferencialmente en las derivaciones del plano frontal (II) porque ellas muestran mejor el fin de la onda T lo que no ocurre en V3 como Adail mostró.**
4) **Atletas con bradicardia con frecuencia tienen concomitantemente arritmia sinusal fásica o respiratoria coincidente con los momentos de inspiración y espiración Por eso debería medir en tres ciclos sucesivos y sacar la media. Evitando cuando posible medir aquellos ciclos con gran variación**
5) **El QTc es mas largo en el sexo femenino , y con el pasar de los años, y después de despertar.**

Esta atleta está con una frecuencia cardiaca por Vuelta de 50lpm
Si utilizamos el metodo de la tangente tiene un QT de 480 a 520ms(primer latido) es decir largo.y si medimos hasta el fin de la pendiente mayor. El Segundo latido es menor



Limite inferior para mujer 0, 382 segundos; Limite superior 463ms (1)

Sagie A, et al. (1992). An improved method for adjusting the QT interval for heart rate (The Framingham Heart Study). Am J Cardiol 70(7):797-801

QT INTERVAL OR ELECTRIC SYSTOLE

CONCEPT: interval between the first recognizable part of QRS up to the final recognizable area of the T wave (the latter may be hard to determine precisely).The end of T is defined as the return of the T wave to the T-P baseline. Therefore, we have to correct QT duration (QTc) according to the rate using the formula proposed by Bazett in the 1920s,(Bazett 1920) where the corrected QT is calculated by:

Concept on QT interval and QT corrected or QTc estimation by using Bazzet's formula.

$$QTc = \frac{\textbf{measured QT}}{\sqrt{\textbf{RR}}}$$

Bazett´s formula has been criticized because it tends to provide an inappropriately short QTc at slow rates and inappropriately long QTc at higher rates. Several competing methods have been developed:

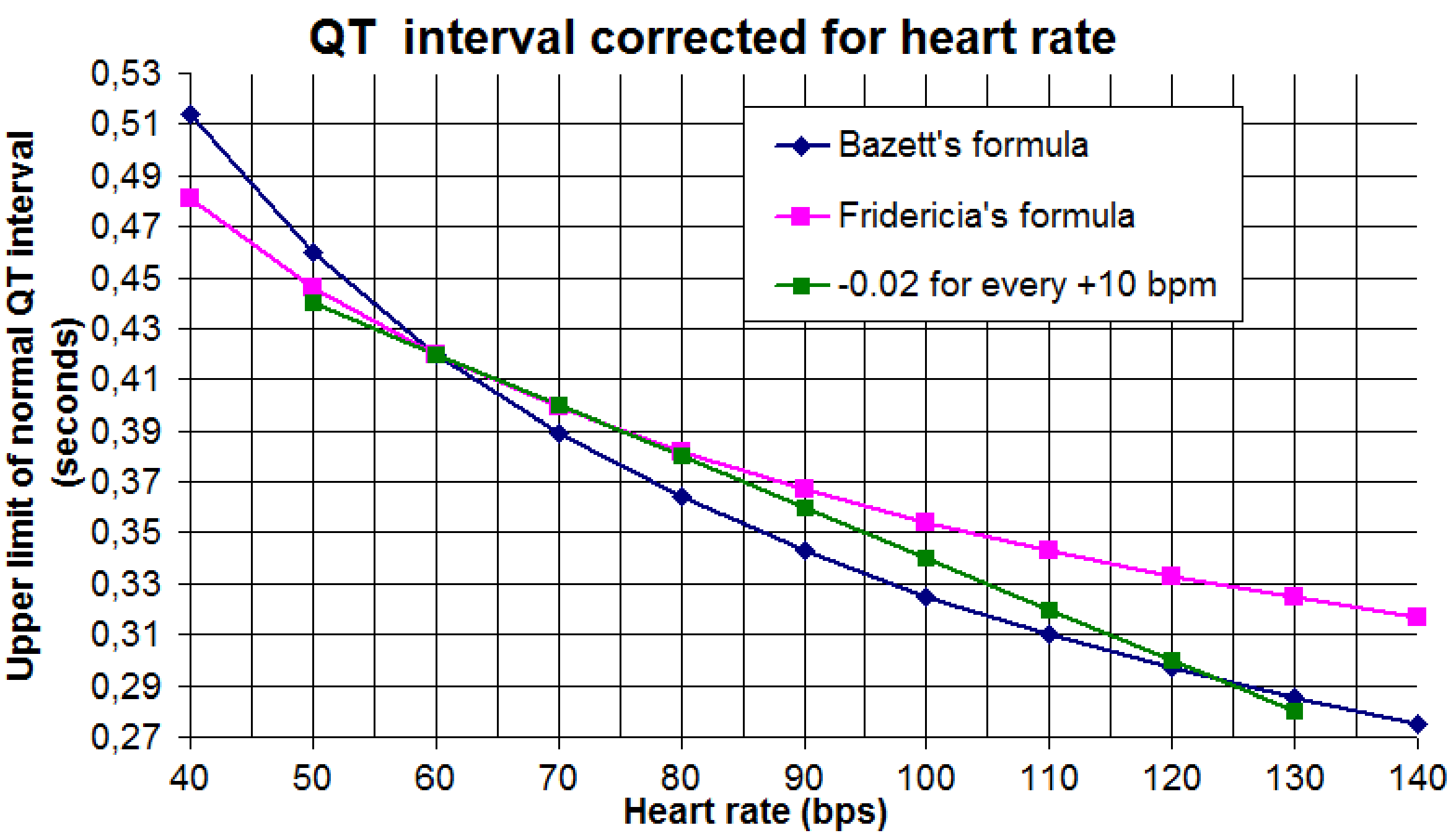
- (Fridericia 1920): **QTcF=QT/3√RR** published an alternative correction using the cuberoot of RR.
- Framingham: QTc = QT + 0.154 (1-RR)
- Hodges: QTc=QT+105(1+RR-1)

None of the formulas has been shown to be clearly superior, so despite its obvious shortcomings.

Bazett's correction is used for automated analysis and large clinical trials.

QT duration is inversely proportional to heart rate.

The range of normality of QT interval in adults varies between 350 ms and 440 ms. Both short and long QT intervals can be susceptible to life-threatening ventricular arrhythmias.



Upper limit of normal QT interval, corrected for heart rate according to Bazett's formula, Fridericia's formula and subtracting 0.02s from QT for every 10bpm increase in heart rate. Up to 0.42s (≤420ms) is chosen as normal QTc of QTf in this diagram.

Method for measurement of QT interval

When measuring the QT interval, the ECG is best recorded at a paper speed of 50 mm/s and at an amplitude of 0.5 mV/cm using a multichannel recorder capable of simultaneously recording all 12 leads. A tangent line to the steepest part of the descending portion of the T wave is then drawn. The intercept between the tangent line and the isoelectric line is defined as the end of the T wave.w3 The QT interval is measured from the beginning of the QRS complex to the end of the T wave on a standard ECG. There are no available data on which lead or leads to use for QT interval measurement. Traditionally, lead II has been used for QT interval measurement because in this lead, the vectors of repolarization usually result in a long single wave rather than discrete T and U waves.(Garson 1993) Generally, QT prolongation is considered when the QTc interval is greater than 440 ms (men) and 460 ms (women), although arrhythmias are most often associated with values of 500 ms or more. The severity of pro-arrhythmia at a given QT interval varies from drug to drug and from patient to patient. Unfortunately, the extent of QT prolongation and risk of TdP with a given drug may not be linearly related to the dose or plasma concentration of the drug because patient and metabolic factors are also important (for example, sex, electrolyte concentrations, etc). Furthermore, there is not a simple relation between the degree of drug induced QT prolongation and the likelihood of the development of TdP, which can occasionally occur without any substantial prolongation of the QT interval.

The QT interval is influenced by heart rate. The RR interval preceding the QT interval should be measured for rate correction. Several formulae may be used to correct the QT interval for the biophysical effect of heart rate (QTc), but none is perfect. The most commonly used formulae are Fridericia's cube root formula (QTc = QT/RR1/3) and Bazett's square root formula (QTc = QT/RR1/2). Of the two, Bazett's formula is the more popular, but Fridericia's correction is preferred because it is more accurate at the extremes of physiological heart rate.w4 w5 Apart from heart rate, the duration of the QT interval is also subject to the techniques of recording and measurement error of the QT interval, sympathovagal activity, drugs, genetic abnormalities, electrolyte disorders, cardiac or metabolic diseases, changes of cardiac afterload, and diurnal variation which can be

up to 75–100 ms. It is important to remember that for every individual there is a different relation between the QT interval and the heart rate. Although the rate–correction formulae are useful clinically, they may not be accurate enough, especially when assessing the minor changes of the QT interval induced by drugs. The suggested QTc values using the Bazett's formula for diagnosing QT prolongation are outlined in table 1.(Moss 1992)Newer repolarisation parameters such as QT dispersion (maximum – minimum QT intervals) on the 12 lead surface ECG, which is considered to be an indirect measure of spatial heterogeneity of repolarization, may be useful in assessing drug efficacy and safety. In one important study, patients who received class 1a antiarrhythmic drugs and developed TdP had significantly increased precordial QT interval dispersion.w6 In contrast, patients receiving amiodarone or class 1A antiarrhythmics without TdP did not have increased QT dispersion, although the QT interval was noticeably prolonged.w6 Thus, spatial heterogeneity/dispersion of the ventricular repolarization process may be required in addition to QT prolongation for the genesis of TdP. Although the use of QT dispersion in the assessment of drugs that prolong the QT interval needs further confirmation, it may provide information about the clinical significance of QT prolongation

Upper limit of normal QT interval, corrected for heart rate according to *Bazett's formula*, Fridericia's formula(Fridericia 1920) and subtracting 0.02s from QT for every 10bpm increase in heart rate.(Yanowitz 2010) Up to 0.42s (≤420ms) is chosen as normal QTc of QTf in this diagram.

Table 1

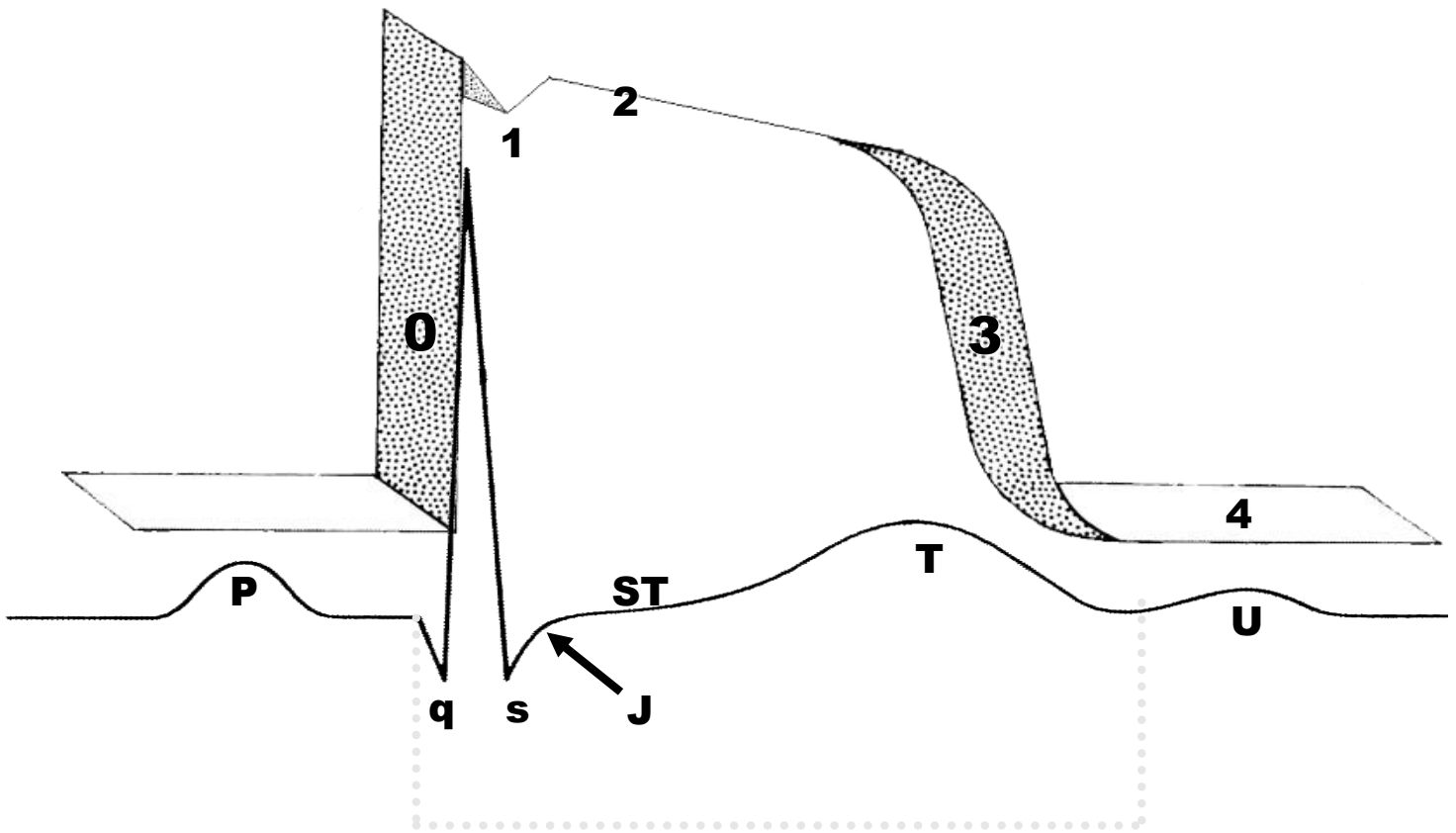
Normal value (using the Bazett's formula)	**350 to 440 ms or 446 + - 15%**
Short QT/QTc interval	< 330 ms
Long QT/QTc interval	> 450 ms

Definitions of normal QTc varies around being equal to or less than 0.40 s (≤400ms),(1) 0.41s (≤410ms),(2) 0.42s (≤420ms) or 0.44s (≤440ms). For risk of sudden cardiac death "Borderline QTc" in males is 431-450 ms, and in females 451-470 ms. An "abnormal" QTc in males is a QTc above 450 ms, and in females, above 470 ms.

If there is not a very high or low heart rate, the upper limits of QT can roughly be estimated by taking QT=QTc at a heart rate of 60 beats per minute (bpm), and subtracting 0.02s from QT for every 10bpm increase in heart rate. For example, taking normal QTc ≤ 0.42s, QT would be expected to be 0.42s or less at a heart rate of 60bpm. For a heart rate of 70 bpm, QT would roughly be expected to be equal to or below 0.40s. Likewise, for 80 bpm, QT would roughly be expected to be equal to or below 0.38s.

1. Goldenberg I, Moss AJ, Zareba W. QT interval: how to measure it and what is "normal". J Cardiovasc Electrophysiol. 2006 Mar;17(3):333-6.
2. Campbell RW, Gardiner P, Amos PA, et al. Measurement of the QT interval. Eur Heart J. 1985 Nov;6 Suppl D:81-3.

Normal values of the QT interval



QT interval or electric systole

Normal value: 350 to 440 ms or 446 + - 15%
< 330 ms: short QT
> 450 ms: long QT

Abnormal intervals

If abnormally prolonged or shortened, there is a risk of developing ventricular arrhythmias.

Genetic causes: An abnormal prolonged QT interval could be due to Long QT syndrome, whereas an abnormal shortened QT interval could be due to Short QT syndrome. The length of the interval was found to associate with variations in NOS1AP gene.(Arking 2006)

Due to adverse drug reactions: Prolongation of the QT interval may be due to an adverse drug reaction(Leitch 2007) Many drugs such as haloperidol(Wenzel 2011), ZELBORAF, and ziprasidone, and methadonecan prolong the QT interval. Some antiarrhythmic drugs, like amiodarone or sotalol work by getting a pharmacological QT prolongation. Additionally, some second generation of antihistamines, such as astemizole, have this effect. Additionally, alcohol in high blood concentrations prolong the QT interval.(Aasebo 2007) A possible interaction between selective serotonin reuptake inhibitor and thiazide diuretics is associated with QT prolongation.(Tatonetti 2012)

Due to pathological conditions: Hypothyroidism, a condition of low function of the thyroid gland, can give QTc prolongation at the ECG. Acute hypocalcemia causes prolongation of the QT interval, which may lead to ventricular dysrhythmias. A shortened QT can be associated with congenital short QT syndrome, idiopathic ventricular fibrillation, Brugada syndrome, early repolarization syndrome, hypercalcemia, chronic fatigue syndrome and in response to atropine, catecholamine and hyperthermia. (Bjerregaard 2010)

Use in drug studies for FDA approval

Since 2005, the FDA and European regulators have required that nearly all new molecular entities are evaluated in a Thorough QT (TQT) study to determine a drug's effect on the QT interval.(1) The TQT study serves to assess the potential arrhythmia liability of a drug. Traditionally, the QT interval has been evaluated by having individual human readers measure approximately nine cardiac beats per clinical timepoint. However, a number of recent drug approvals have used a highly automated approach, blending automated software algorithms with expert human readers reviewing a portion of the cardiac beats, to enable the assessment of significantly more beats per timepoint in order to improve precision and reduce cost.(2) As the pharmaceutical industry has gained experience in performing TQT studies, it has also become evident that traditional QT correction formulas such as QTcF, QTcB, and QTcI may not always be suitable for evaluation of drugs impacting autonomic tone.(3) Current efforts are underway by industry and regulators to consider alternative methods to help evaluate QT liability in drugs affecting autonomic tone, such as QT beat-to-beat and Holter-bin methodologies.(4)