

Recognition of Drug-Induced Prolonged QT

Measure QT and RR Intervals

Grid values are for ECGs recorded at 25mm/sec

Time →

Voltage ↑

0.1 mV

0.2 sec

0.04 Sec

1 mV

RR Interval

QRS Complex

P Wave

ST Segment

T Wave

U Wave

PR

QRS

QT

Correct for Heart Rate

Correction Formulas

Bazett: $QTc = QT * (HR/60)^{1/2}$

Correction of QT for heart rate is still a large area of study. Other formulas exist (e.g., Fridericia, Framingham, or Hodges). Use one and be consistent.

Obvious Long QT: $QT > \frac{1}{2} RR$

Normal QT

Long QT

Check QTc versus Normal Limits

Persons (no.)

Break reflects 1-in-3000 estimated incidence of QTS

Normal Male

Normal Female

Overlap Zone

360 440 482 520 600

Corrected QT Interval¹

3,000

470 msec, 99th percentile in males

480 msec, 99th percentile in females

Risk Factors

Genetics

ECG from LQT2 Patient

"Current evidence suggests that 5 to 10 percent of persons in whom torsade de pointes develops on exposure to QT-interval-prolonging drugs harbor mutations associated with the long-QT syndrome."¹

Electrolytes

Example of Hypokalemia

Imbalance in K, Ca, or Mg can lead to higher risk. In this example, lead II exhibits TP fusion while in V4-V6 these waves are clearly separated.

Brady-Arrhythmia

Atrial fibrillation with low heart rate and prolonged QT. Long followed by short RR leads to Torsade de Pointes.²

Poor Liver or Heart Function

Liver

Poor function can lead to toxic levels of prescribed drug.

Heart

Cardiac ischemia can prolong QT.

Low ejection fraction can increase risk of arrhythmic death due to prolonged QT.

Drugs

- Anti-depressants
- Anti-psychotics
- Anti-biotics
- Anti-arrhythmics
- Etc.

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For more details check www.azcert.org

Tools and Strategies for Measuring Difficult ECGs

Artifact

Tracing A

Median A

Magnified Median

Tracing B

Median B

Raw Rhythm Tracings

The artifact in tracing A is too excessive. The T-wave is not even visible. Advise repeat ECG. Tracing B exhibits a T-wave but the measurement of QT could be inconsistent due to baseline sway and muscle artifact. Select the best complex for measurement.

Median Complexes

A median complex is formed by taking the median value, at each sample time, from the superimposed row beats. The result is a cleaner, representative complex for measurement.

Flat T-wave in Limb Leads - Use All Leads

I aVR V1 V4

II aVL V2 V5

III aVF V3 V6

All Medians Superimposed

Median - Lead II

The T-wave in lead II is flat, which makes measurement difficult or inaccurate. Check all leads. Use longest interval. GE's Marquette® 12SL™ program superimposes median complexes from each lead. The automated QT measurement is from earliest QRS onset to latest T-offset.

Bi-Phasic T-Wave - Include Terminal Portion

I aVR V1 V4

II aVL V2 V5

III aVF V3 V6

All Medians Superimposed

Median - Lead V2

T-wave in lead V2 is bi-phasic. Do not define baseline based on the end of the T-wave. This can lead to the mistake of defining T offset within the T wave. QRS onset should define baseline. The entire wave of repolarization includes T and T'. Use all leads to assist in defining the end of repolarization.

Calculating QTc in the Presence of Varying Heart Rate

RR₁ RR₂

RR₂ > RR₁ and QT₂ > QT₁

QTc = (QT_{c1} + QT_{c2}) / 2

QT via Median

QTc via Average RR

QT is varying with heart rate. An overall QTc needs to be determined.⁴ Some recommend an average obtained from the shortest and longest preceding RR intervals. Others perform the average over 3 to 5 consecutive beats. Instead, GE's Marquette 12SL program uses QT from the median beat and the average RR.⁵

TP Fusion - Measuring QT in Presence of High Heart Rates

Tangent

Baseline

QT

Median - Lead V3

Single Lead: Use Tangent Method

At fast heart rates, the P-wave fuses with the T-wave, sometimes making it infeasible to measure the end of the T-wave. If possible, record and measure the QT at a lower heart rate. In a single lead, use tangent method to identify the end of the T-wave.

Inspect All 12 Leads

In normal sinus rhythm, leads V1 and II have the largest P waves. Other leads may reveal separation of P and T. Tic marks on 12SL medians report can be used to inspect 12SL measurements.

Do Not Include Normal U-Waves

Tangent Method

Median - Lead V3

Separate T and U-Waves

T and U waves are not superimposed and can be separated. These are normal U-waves. Either use tangent method for single lead or inspect other leads without U-waves in order to determine T-offset.

TP Fusion - Long PR Interval

Median - Lead V3

Tangent Method Limitations

Due to a long PR interval, the P wave is superimposed on the T-wave. In lead II, the T wave appears flat. The tangent method will be difficult to apply. In V3, the tangent method will result in a longer PR interval than inspecting all the leads.

Inspect All 12 Leads

By inspecting all leads, it is clear the T-wave shape is due to a long PR interval. In leads V1 and V5, the P and T-waves are separate.

Include U-Wave When Abnormal or Unable to Separate from T-Wave

All Medians Superimposed

Abnormal U-Waves - Cannot Separate

These are abnormal U-waves. The U-waves are too large and fused with the T-wave. Include U-wave for proper measurement of QT interval.

T-wave Before and After Drug Effect

Before

After

T-wave Notch