Presenter Disclosure Information

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DISCLOSURE INFORMATION

No relationships exist regarding this presentation

Presentation Title:

How to Measure QT

Background

- Abnormally long and short QT intervals are associated with increased risk for life-threatening ventricular arrhythmias and sudden cardiac death

- In recent years, various methods for QT interval measurement have been developed including:
  - ➢ Individual-based corrections for repolarization duration
  - ➢ Quantitative assessment of repolarization morphology
  - ➢ Correction for repolarization dynamicity
  - ➢ Analysis of repolarization variability

Purpose of Presentation

- To describe clinically relevant methods for assessment of QT interval duration from a 12-lead ECG:
  - **Focus will be on simple methods that can be utilized in day to day practice for the diagnosis of long QT syndrome (LQTS) and other repolarization disorders**
  - **Using visual and manual assessment**

ECG Assessment

Methods of ECG Assessment

- Manual ECG readings:
  - ➢ Performed using visual determinations:“eyeball”/caliper techniques
- Digitizing methods:
  - ➢ Employ a digitizing pad, magnifying lamp, and pointing device to identify the beginning and end of the QT interval
  - ➢ Have an accuracy levels of 5 ms
- On-screen computerized methods:
  - ➢ Displays recorded ECGs on a computer screen
  - ➢ Provides high-quality ECG data
  - ➢ Recommended at core laboratories

Manual Assessment I

- The accuracy levels of manual determination with a caliper is 20 to 40 ms
- A standard 12-lead ECG tracing at 25 mm/s paper speed at 10 mm/mV amplitude is adequate
- The QT interval should be determined as a mean value derived from at least 3-5 cardiac cycles
- Measured from the beginning of the earliest onset of the QRS complex to the end of the T wave

Manual Assessment II

- The QT measurement should be made in leads II, and V5 or V6 with the longest value being used
- The main difficulty lies in identifying correctly the point where the descending limb of the T wave intersects the isoelectric line, particularly when there are T and U waves that are close together
- In general, biphasic T waves are frequently present in multiple leads, whereas discrete and separate low-amplitude U waves are best seen in the lateral precordial leads
  - See next slide for examples of identifying T-wave end

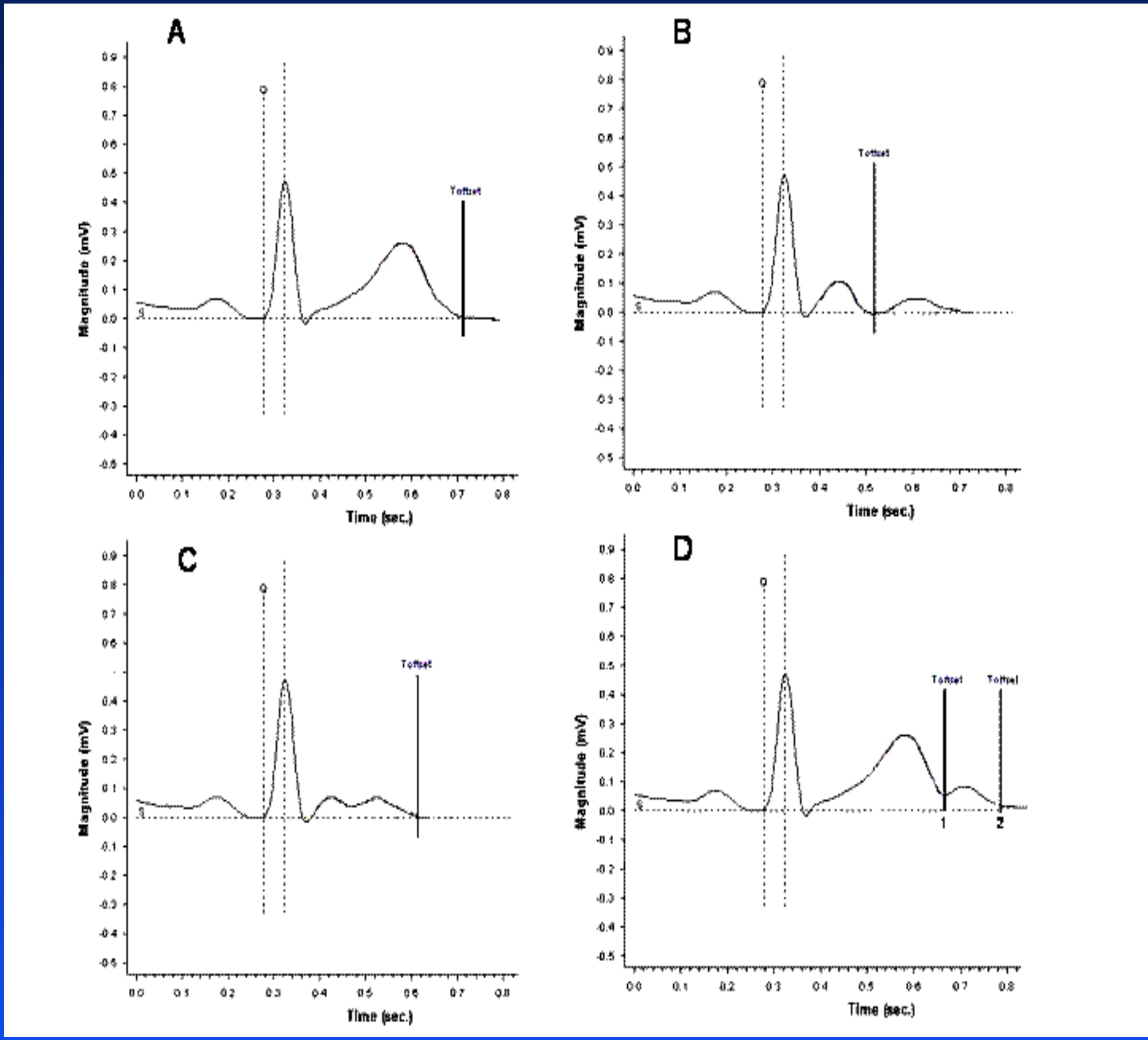
Identifying T-Wave End

A. The end of the T wave is identified when its descending limb returns to the TP baseline when it is not followed by a U wave

B. The end of the T wave is identified when its descending limb returns to the TP baseline when it is distinct from the following U wave

C. When T wave deflections of equal or near equal amplitude result in a biphasic T wave, the QT interval is measured to the time of final return to baseline

D. If a second low-amplitude repolarization wave interrupts the terminal portion of the T wave , it is best to record both the QT interval (T wave offset measured as the nadir between the T and U wave) and the QTU interval (repolarization offset measured at the end of the second wave).



QRS Interval

- The QRS interval can be modified by several factors:
  - Bundle branch block,
  - Class 1C antiarrhytmic drugs
  - Preexcitation
- The QT interval in these cases may not be an accurate reflection of repolarization duration
- The measure of the JT, from the S wave offset to T wave end, may be used in these cases but normal standards for the JT interval are not well established

Adjustment for heart rate

Correction formulae

- The time-duration intervals are influenced by heart rate (R-R cycle length), so heart rate correction is required in the analysis of repolarization duration
- Various heart rate correction formulae have been developed in order to determine whether the QT interval is prolonged in comparison to its predicted value at a reference heart rate of 60 beats per minute (i.e. a RR interval of 1.0 second)
- These formulae have been derived mainly from resting ECGs and therefore require a stable sinus rhythm without sudden changes in the RR interval

QT Correction Formulae

Method	Formula	Comment
Exponential		
Bazett	$QTc = QT/RR^{1/2}$	Widely used; may give erroneous results at both slow and fast heart rates.
Fridericia	$QTc = QT/RR^{1/3}$	Widely used; May give more consistent results at fast heart rates.
Linear		
Framingham	$QTc = QT+0.154(1-RR)$	May have more uniform rate correction over a wide range of heart rates.
Hodges	$QTc = QT+1.75(HR-60)$	
Rautaharju		May have more uniform rate correction over a wide range of heart rates
Females and males <15 and >50 years	$QTI = (QT[HR+100])/656$	
Males 15-50 years	$QTI= 100(QT)/([656/(1+0.01HR]) + 0.4age - 25)$	
Logarithmic		
Ashman	$QT = K1 \times \log(10 \times [RR +])$	At low heart rates, the values are too low.
Adult men:	$K2= 0.07$, and $K1 = 0.380$	
Adult women	$K2= 0.07$, and $K1 = 0.390$	

Correction Formulae: Summary of Data

- There is no general consensus on the best formula to be utilized in clinical practice
- In resting conditions, with heart rates in the 60 to 90 beats/min range, most formulae provide almost equivalent results for the diagnosis of QT prolongation
- The rate dependence of the QT interval is probably best described by an exponential relation. However, in the normal heart rate range, the QT-RR relation is approximately linear

Heart rate correction in patients with sinus arrhythmias

- Assessment of repolarization dynamicity may be required in patients without a stable sinus **rhythm:**
  - **The QT interval adapts to heart rate changes with a delay known as QT hysteresis or QT lag**
  - **When the change in the heart rate persists for several minutes, the QT lag is visible on the trend of QT and RR intervals**
  - **The QT adapts more slowly to decelerations than to accelerations of the heart rate**
  - **The plot of QT versus RR intervals during dynamic adaptation of repolarization to heart rate changes forms a loop known as hysteresis**
  - **QT/RR hysteresis pattern is highly individual and therefore, methods which take into account individual profiles are required.**

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Normal values of the QT interval

- **Most reported criteria for normal and abnormal values for QTc are derived from Bazett's formula**

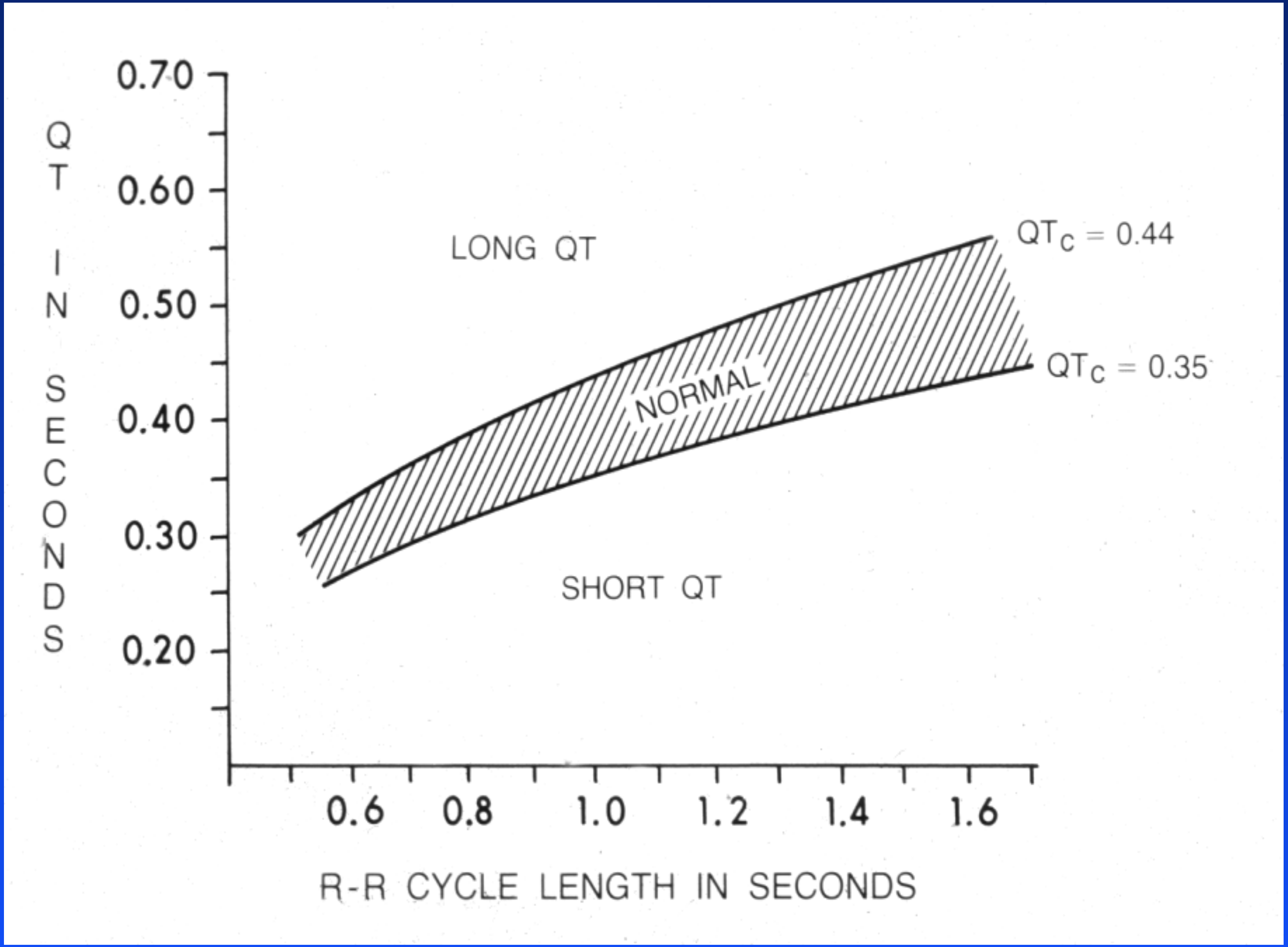
- **A study that was carried out at the Heart Research Follow-Up Program showed:**
  - ➢ **Stable QTc for children, with no gender difference**
  - ➢ **A significant difference between adult men and women in a healthy population**

Moss AJ. Measurement of the QT interval and the risk associated with QTc interval prolongation: a review. Am J Cardiol 1993;72:23B-25B

Suggested Bazett-corrected QTc values for diagnosing QT prolongation

Rating	1-15 years (msec)	Adult Male (msec)	Adult Female (msec)
Normal	<440	< 430	< 450
Borderline	440-460	430-450	450-470
Prolonged	>460	> 450	> 470

Simple graphical display of lower and upper limits of QT interval for different RR cycle lengths based on population studies



Repolarization Morphology

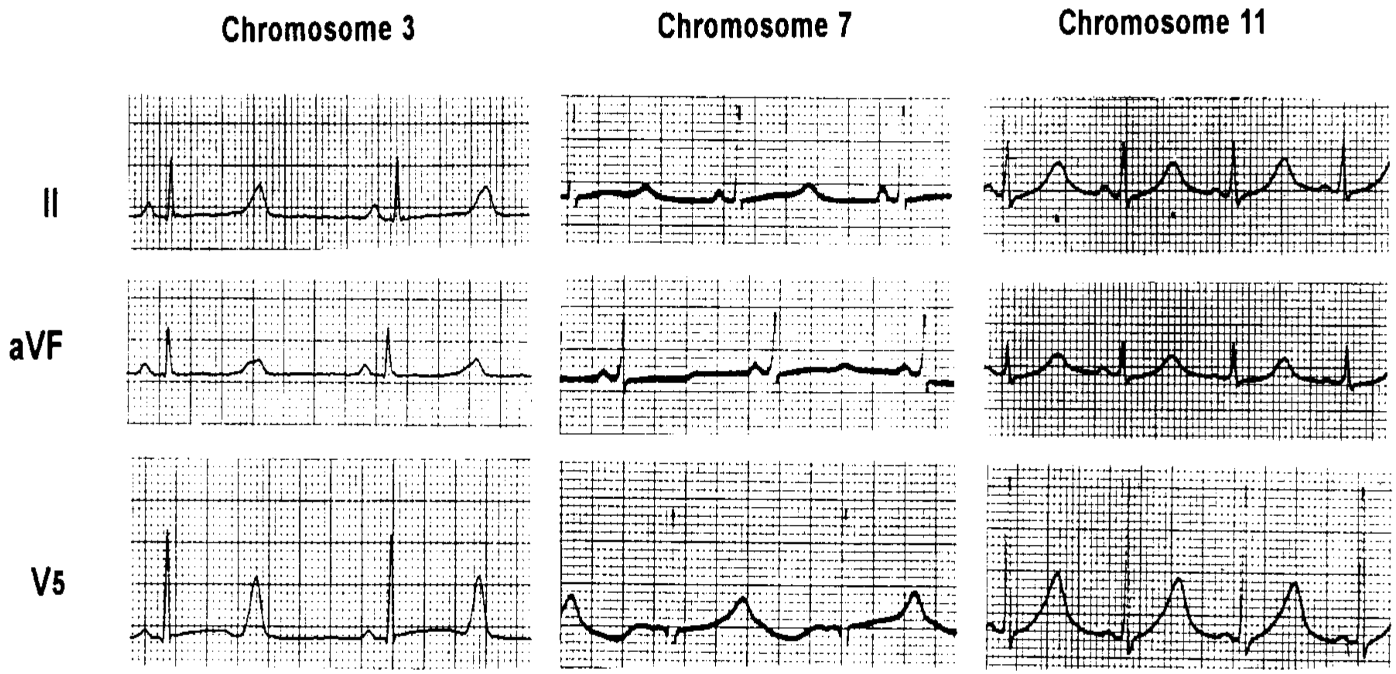
Quantitative Assessment of Repolarization Morphology

- Quantitative repolarization asssessment has recently become feasable for the following parameters:
  - Symmetry of the T wave
  - T wave area
  - The interval between the end of the S wave
- Requires computer software and electronically stored ECG data.

Visual Assessment of Repolarization Morphology in the Congenital Long QT Syndrome

- LQT1:
  - A single, smooth, broad-based T wave is common, as well as a late-onset normal-appearing T wave
- LQT2:
  - Bifid T waves are the hallmark ECG feature
- LQT3:
  - T-waves are typically late-onset, prominent, and usually peaked

T-wave Morphology in LQTS by Genotype



Moss AJ, et al. Circulation 1995;92:2929-2934

Other ECG Recording Techniques for QT Assessment

Holter

- Holter monitoring is not well standardized to serve in the primary assessment for ventricular repolarization analysis
- Hother may sometimes be employed for the detection of extreme QT interval events that occur infrequently during the day
- QT intervals measured by Holter do not correspond quantitatively to those for standard ECGs, and therefore are not suitable for direct comparison

Exercise Testing

- Can be used for evaluation of QT prolongation during exercise and recovery periods
- May be employed for the detection of extreme QT interval events that occur infrequently during the day
- Both intermittent 12-lead ECGs or continuous multichannnel ECG recordings can be used
- The adaptation of QT interval duration to heart rate is not instantaneous, therefore, substantial errors may be introduced if nonstationary episodes are analyzed

QTc Variability

- Recent analysis from the International LQTS Registry demonstrates that there is individual subject variability in QTc duration on repeat ECGs during long-tem follow-up
- Therefore several ECGs recorded over time should be more useful in identifying subjects with abnormally long or short QT intervals than simply one baseline ECG recording
- The maximum QTc on serial follow-up was shown to be the most powerful predictor of cardiac events in LQTS children

Goldenberg I, et al.Corrected QT variability in serial electrocardiograms in long QT syndrome: the importance of the maximum corrected QT for risk stratification. J Am Coll Cardiol. 2006 Sep 5;48(5):1053-5.

Conclusions

- Routine measurement of the QT interval requires the use of uniform criteria for the determination of:
  - T wave offset (especially when there is partial superimposition of the T and U wave)
  - Adjustment for heart rate
  - T wave morphology.
- Experience and training play an important role in the accurate measurement of the QTc interval