The QT Interval in Clinical Practice

SECTION 2: Measuring the QT interval & normal values for the QT Interval

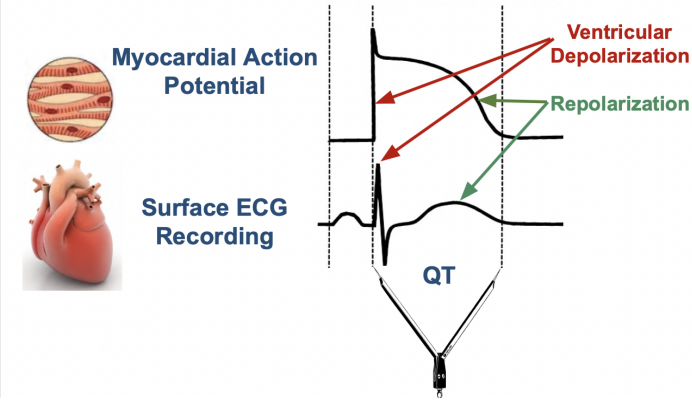
The objective for Section 2 of The QT Interval in Clinical Practice is to review how to accurately measure the QT interval in clinical practice.

Clinical Guideline for Measuring the QT Interval:

In 2009, the American Heart Association, the American College of Cardiology and the Heart Rhythm Society jointly published consensus guidelines for how and why to measure the QT interval as Part IV of Standardization and Interpretation of the ECG. The following charts are based on these guidelines.

The QT Reflects the Sum of Ventricular Action Potentials:

To understand the origin of the QT interval, it is important to understand how it relates to the action potentials that depolarize and repolarize each heart cell.



The upper tracing represents an action potential recorded from a single heart cell using a micropipette electrode. The lower tracing is an ECG lead and shows how all of the ventricular action potentials appear when their electrical fields summate and reach the body surface.

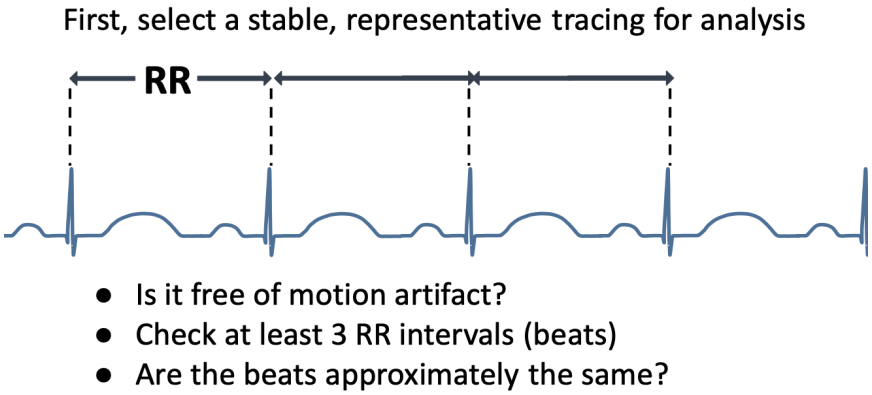
Ventricular depolarization begins with the upstroke of the cells' myocardial action potentials and is displayed as the initial deflection of the QRS complex. When the cells begin to repolarize,

the electrical potential returns to baseline, generating the T wave. The end of the T wave represents the end of ventricular muscle repolarization.

To summarize, the QT interval represents the time from the earliest ventricular depolarization to the time when repolarization of the ventricular muscle is complete.

Measuring QT Intervals:

The first step in measuring the QT interval is to select a stable, representative tracing for analysis, such as this.



Be sure that it is free of motion artifacts and select at least three consecutive RR intervals for analysis making sure they are nearly the same and vary by less than 10%.

Heart Rate Affects QT Duration:

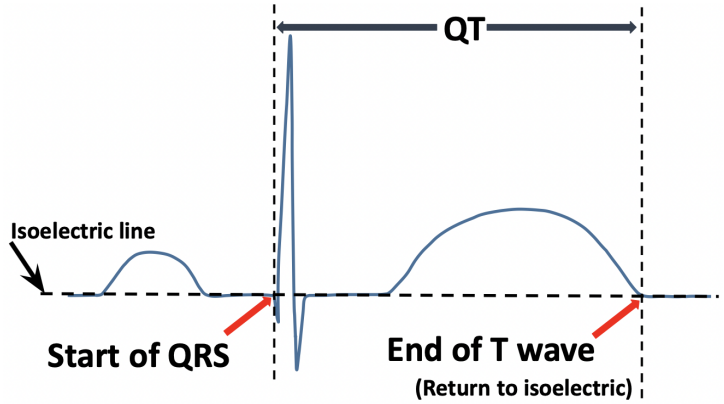
As mentioned earlier, the heart rate influences the QT interval and an accurate interpretation of the QT interval requires an accurate measurement of the heart rate. Once the heart rate has stabilized, the RR interval can be measured and used to calculate the heart rate associated with the next QT interval.

Activity and emotion can alter the heart rate and the patient should ideally be allowed to rest quietly for at least two to five minutes before recording the ECG. As the patient rests and their heart rate decreases, the QT interval should lengthen. When the heart rate speeds up again, there is a normal physiologic shortening of the QT. This adaptation of QT to a sudden change in heart rate is not instantaneous and develops over several minutes, a process termed QT/RR hysteresis.

It is generally assumed that 95% of QT adaptation to a sudden change in heart rate requires about 2 minutes. To reduce the influence of QT/RR hysteresis on measurements, it is recommended that ECGs be recorded after the patient has been supine and resting without being disturbed for five minutes.

Measuring the QT Interval:

Once you have chosen the beat and measured its preceding RR interval, we can now measure its QT interval.



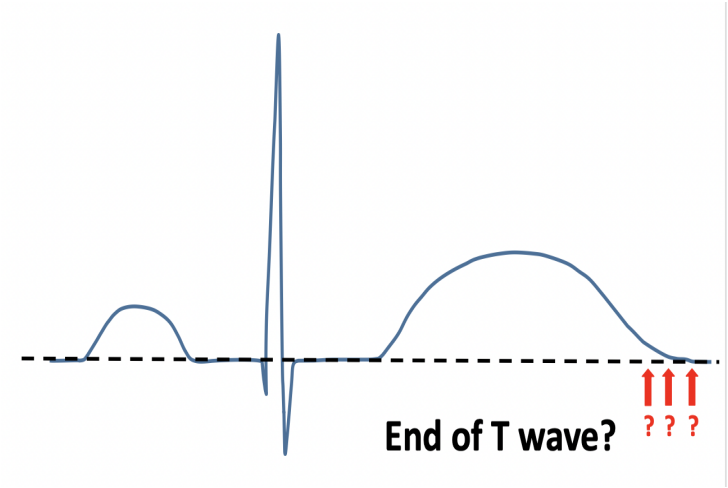
For each heartbeat, one should first draw a straight line to define the isoelectric line. Next, mark with a vertical line the earliest deflection of the QRS complex. Then, draw a vertical line at the point in which the T wave has returned to meet the isoelectric line.

This is the method to use when one has available only a single lead and when there is a clear termination point for the T wave, which is often not the case. The degree and type of QT analysis depends upon the type of ECG data that is available.

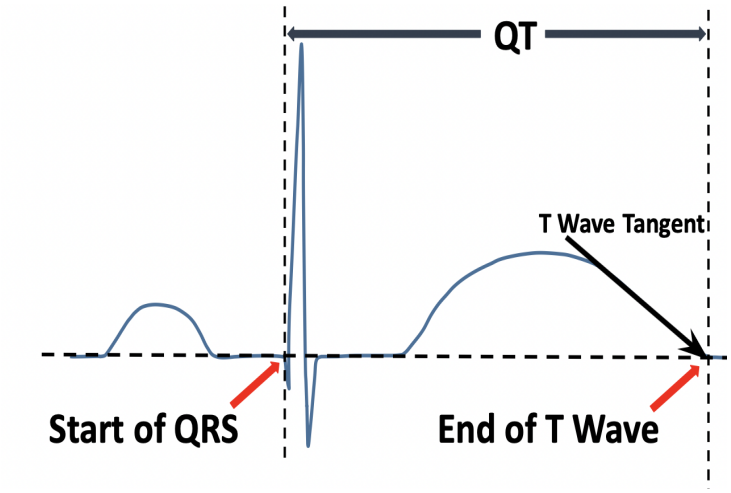
In certain clinical settings such as an intensive care unit or ambulance, only a single lead from a monitor might be available. When additional leads are available, it is recommended that one look at all available leads simultaneously and pick the interval that begins with the earliest QRS deflection and ends with the latest return of the T wave back to the isoelectric baseline.

Measuring the QT Interval: Slurring of Terminal T Wave:

A frequent challenge when measuring the QT interval occurs if the end of the T wave is slurred, making it difficult to determine the end of the T wave.



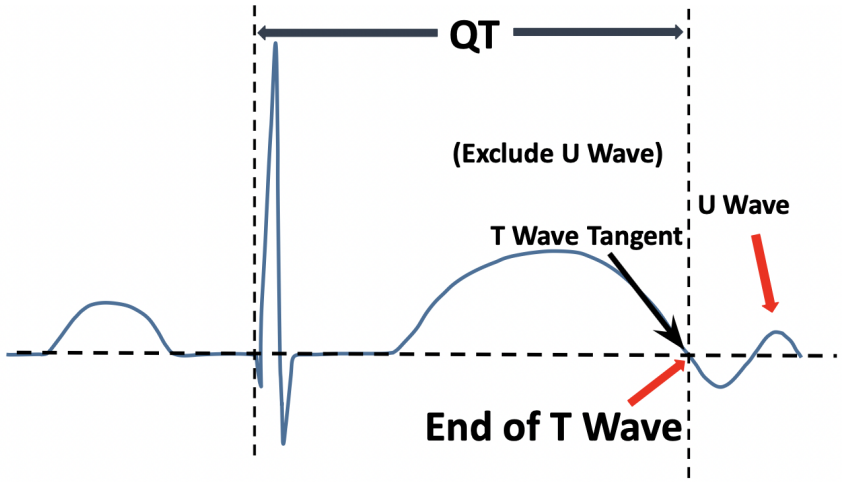
In cases with slurred T waves, it is conventional to use the "tangent" method to find the end of the T wave.



First draw a tangent to the down-sloping terminal portion of the T wave and mark the end of the T wave as the point where the tangent transects the horizontal isoelectric line (dashed line).

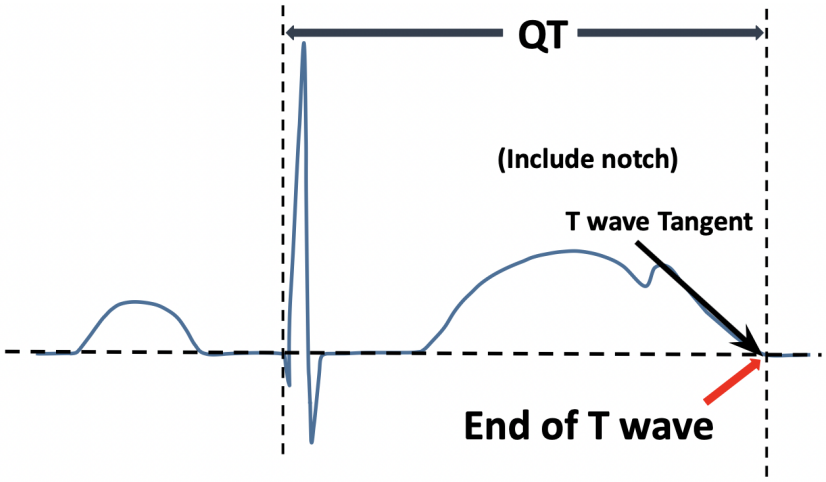
Measuring the QT Interval: Prominent U Wave:

If there is a prominent U wave present, it is recommended that the U wave be excluded from the measurement and a tangent to the down-sloping portion of the T wave be used to identify the point at which it crosses the isoelectric line.



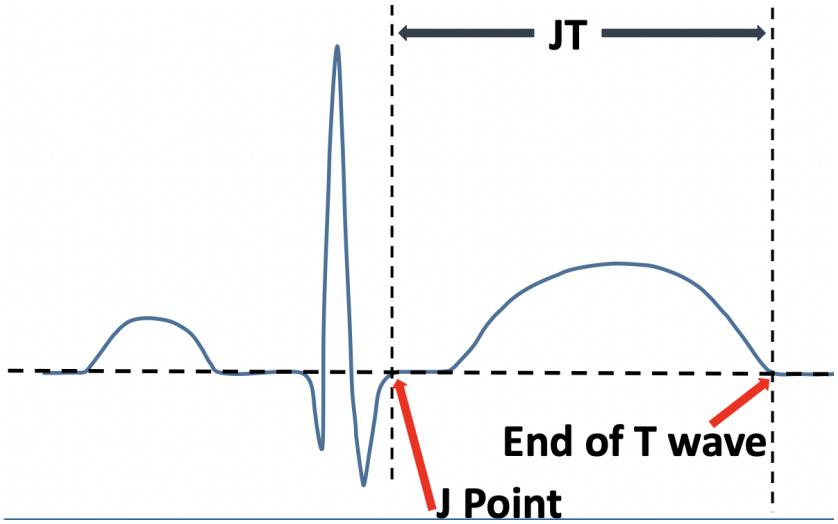
Measuring the QT Interval: Notched T Wave:

If the T wave is bifid or notched as shown in this tracing, it is recommended that the end of the T wave be determined using a tangent drawn to include the notched portion of the T wave.



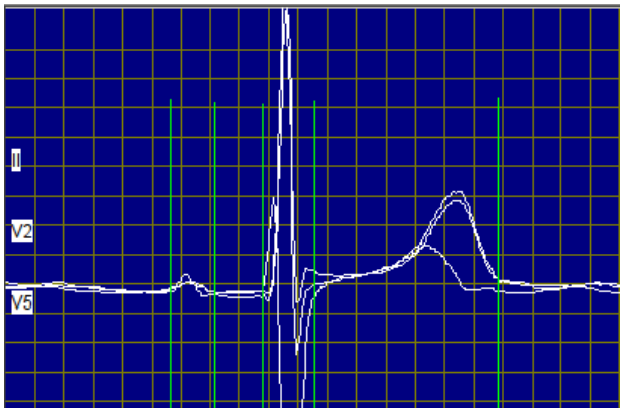
Measuring the QT Interval: When QRS is > 120 msec:

If the QRS is abnormally wide and is 120 msec or greater, it is recommended that the JT interval be recorded. The J point is the end of the QRS complex, i.e., where the QRS returns to the isoelectric line. Interpretation of JT intervals is considered briefly in forthcoming segments.



QT Varies with Lead Selection:

This is a photo taken of a display from a research system used to measure ECG intervals.

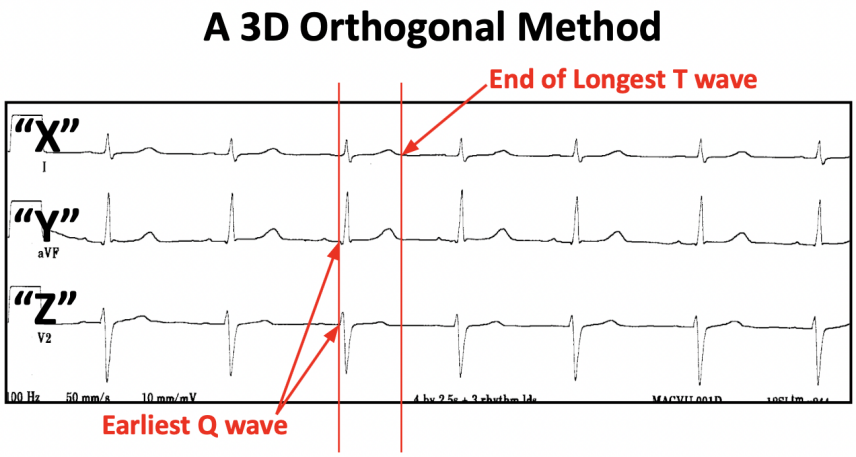


The monitor displays three superimposed leads where the green cursors mark the computer-derived points that define (from left to right) P wave duration, QRS duration and the end of the T wave. The system allows the users to move the green cursors when the operator has concluded that the cursors are not correctly placed. Again, one can see how dramatically

the QT interval can vary between leads, as shown by the two red arrows. This difference is sometimes referred to as “QT dispersion.”

3-Dimensional QT Measurement:

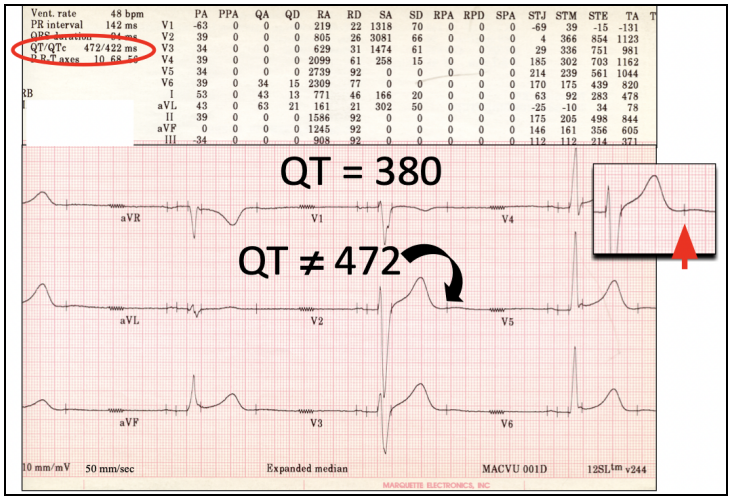
When feasible, a three-dimensional approach should be used to more accurately measure QT intervals. This high-speed tracing shows the three leads (I, aVF and V_2) that most closely approximate the orthogonal leads (X, Y and Z). The earliest Q is seen in aVF and V_2 but the latest end to the T wave is in Lead I.



Therefore, for greatest accuracy one should use multiple simultaneous leads to define the earliest start of the QRS and measure to the point with the latest ending of the T wave. When it is not feasible to use three-dimensional analysis with multiple leads, one should try to use the same lead for making comparisons over time or under varying conditions.

Computer QT Measurement Error:

As mentioned above, modern ECG machines are programmed to make an initial analysis of intervals that can be reviewed and hopefully confirmed by a qualified reader. It is important to be aware that the computerized measurement of the QT interval can often be incorrect, as can be seen in this tracing. The computer reports that the QT interval is 472 msec.



This tracing is printed at 50 mm/sec (twice usual) to more easily visualize the end of the T wave. The ECG instrument has been programmed to mark on the tracing the points that it used to calculate intervals. The small tick marks can best be seen in the enlarged box. The red arrow points to the computer's tick mark that the computer mistakenly chose as the end of the T wave. This mark, which is well beyond the end of the T wave, results in a value for QT of 472 msec, which is not correct.

The actual value for QT is 380 msec. Approximately ten percent of computerized measurements of a normal QT value are 20 msec shorter or longer than actual values.

Commercial ECG vs. Manual QTc Measurement:

This table compares the accuracy of computer read ECGs using two different commercial instruments (labeled A and B).

Error ≡ >10 msec difference

	ECG Instrument A		ECG Instrument B	
	Errors/Total	%	Errors/Total	%
Placebo	47/720	7	11/108	10
Quinidine	360/1440	25	29/39	74

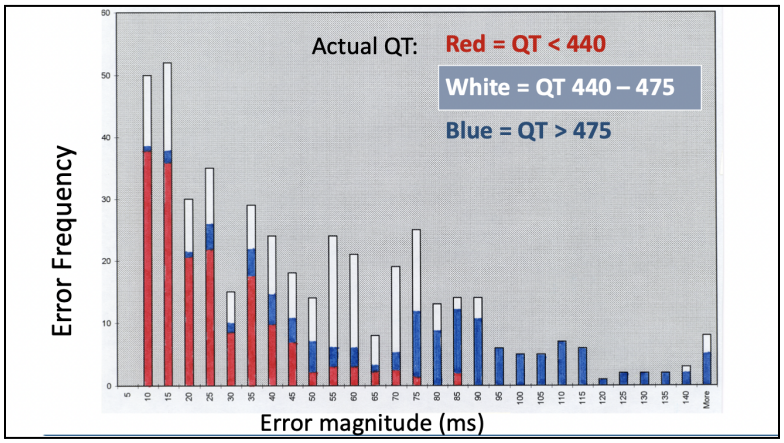
All QT intervals were measured by a cardiologist using a validated program and an electronic digitizing pad with ECGs printed at 50 mm/sec (2x standard) to facilitate identification of the

end of the T wave. ECGs were obtained during treatment with placebo and again after quinidine. Discrepancies greater than 10 msec between the readings made by a cardiologist and those by the instrument were considered to be instrument errors.

Instrument errors were found in 7-10% of the ECGs taken during the placebo period. During quinidine treatment, the QT interval was prolonged and the frequency of errors was even larger, 25% and 74% for the two instruments, respectively.

Error Distribution & Magnitude of QT Change:

This slide shows the relationship between the frequency and magnitude of errors made by machines in measuring the QT interval segregated by the magnitude of the correct value of the QT interval.



The height of each bar represents the fraction of errors plotted with the magnitude of the error on the x axis. The red portion of each bar is for readings that were less than 440 msec and the blue portion is for QT readings greater than 475 msec.

The data show that the computer made larger errors when the true QT value was longer. In some cases, this is most likely due to quinidine-induced slurring of the terminal portion of the T wave, which can make it difficult for the computer to define the end of the T wave.

This is the end of Section 2 and we hope you will continue with Section 3 which examines the effect of heart rate on QT intervals, how to correct for rate differences and calculate QTc values, as well as discussing the normal range for QTc intervals and how the range is influenced by age and biologic sex.