TRAINING GUIDE

QT/QTc Interval Monitoring
ST/AR with IntelliVue Patient Monitor

Patient Monitoring
Introduction

About this Guide

The Philips IntelliVue Patient Monitor is very intuitive and easy to use. This training guide is designed to assist you as a clinician in learning the basic functions of QT/QTc monitoring for telemetry patients. If you have used the IntelliVue Patient Monitor, you will find many similarities and will be able to proceed through certain sections quickly. If the Philips IntelliVue Patient Monitor is totally new to you, this guide will help you to familiarize yourself with the QT/QTc monitoring feature.

Who is this Training Guide for?

This training guide is intended to be used by trained healthcare professionals who are competent in the field of patient monitoring. It serves as a training tool. Before you use the QT/QTc Monitoring feature you must have a comprehensive understanding of the IntelliVue Patient Monitor’s Instructions for Use.

How to use this Training Guide

This training guide uses a self-paced, but highly interactive approach. It will guide you step-by-step through the basic functions of QT Monitoring. It is recommended that you use this guide in conjunction with a running IntelliVue Patient Monitor to see measurement data on the monitor and that you use the monitor with a patient simulator, or place it into Demo mode.

Learn the basics

The performance objectives outline the information presented in this guide for QT/QTc monitoring. The basic information included - when to monitor, how to monitor, alarms and troubleshooting.

Practice on the monitor

To make your learning experience as interactive as possible, the explanatory text is accompanied by practice tasks that help you to practice on the monitor. These tasks are indicated by this pointing finger symbol.

Test your knowledge

At the end, a short quiz to test your knowledge completes your learning experience.¹

¹The tests included in this Guide are provided as a way for you, the learner, to judge your own ability to use the QT Monitoring feature. The tests do not, in themselves, constitute evidence of proficiency.
References

The following items were shipped with your IntelliVue Patient Monitor and should be used as additional sources of information:

• Printed copies of the IntelliVue Patient Monitor Instructions for Use. This is the main reference document for the IntelliVue IntelliVue Patient Monitor with QT Monitoring.

• QT/QTc Interval Monitoring - Application Note 453564115621

• The IntelliVue IntelliVue Documentation DVD, which contains the above documents as pdf files (readable with Adobe Reader), as well all other documents associated with this monitor.

To purchase additional printed copies of any documentation or to purchase additional DVDs or CDs please contact our fulfillment center (Globalware Solutions) by calling 1-800-527-6871; or send an e-mail to Aftermarket@gws.com
QT/QTc Interval Monitoring

Performance Objectives

Upon completion of this module you will be able to:

- Describe the indications for QT interval monitoring.
- Define the QT measurements.
- Obtain an accurate QT interval measured by:
  - Turning On/Off the QT analysis measurement.
  - Identifying the components of an ECG wave used to measure the QT Interval.
  - Select the QT leads.
- Describe the QTc alarms.
- Adjust the QTc interval alarm limits.
- Identifying two factors that can affect the accuracy of QT analysis.

References

For more detailed information regarding the functions described in this section, refer to the following chapter in IntelliVue Information Center *Instructions for Use*:

- QT Monitoring
- QT/QTc Interval Monitoring Application Note - Part Number 4535 641 15621
About the Measurement

The QT Interval

The QT interval is one part of the heart’s electrical signature as recorded by an electrocardiogram (ECG). The QT interval measures the total duration of depolarization (QRS duration) and repolarization phases (ST-T) of the ventricular action potential. The QT interval is measured from the beginning of QRS to the end of T wave, as shown in Fig. 1.

The beginning of the QRS complex can usually be relatively easily identified, however the end of the T-wave can be difficult to determine. One commonly used method is to draw a tangent from the steepest downslope of the T-wave to the intersection of the baseline which is considered the end of the T-wave.

Why measure the QT Interval?

Of special concern in QT monitoring is the administration of QT prolonging drugs to patients identified with risk factors for Torsade de Pointes. Females, older patients and patients with bradycardia, impaired left ventricular function (ischemia, left ventricular hypertrophy), hypokalemia and hypomagnesemia are in this increased risk category.
Current AHA Scientific Statement on Practice Standards for Electrocardiographic Monitoring in Hospital Settings listed the following as indications for QT monitoring:

**Class I**
- Patients administered an anti-arrhythmic drug known to cause Torsade de Pointes
- Patients who overdose from a potentially proarrhythmic agent
- Patients with new-onset bradyarrhythmias
- Patients with severe hypokalemia or hypomagnesemia

**Class II**
- Patients who require treatment with anti-psychotics or other drugs with possible risk of Torsade de Pointes
- Patients with acute neurological events

**Class III**
- Healthy patients administered drugs that pose other risk for Torsade de Pointes

**How the QT Segment is Measured**

The QT values are updated every five minutes except in the initial phase (first five minutes) where they are updated once per minute. Normal or atrial paced beats and beats with a similar morphology are averaged to form a representative waveform for further processing. Normal beats followed by a premature QRS will be excluded from the measurements to prevent the premature beat from obscuring the end of the T-wave. If the algorithm cannot form a representative waveform, for example because the morphology of the beats is too varied, a **Cannot Analyze QT INOP** will be generated after 10 minutes. This is also the case if normal beats have been falsely labelled so that the algorithm does not have enough valid beats to make QT measurements. No QT value is calculated if the QT-HR is >150 bpm (Adult) or >180 bpm (Pedi/Neo). Because of the different algorithm approaches, a QT/QTc measurement from a diagnostic 12-lead program may differ from the realtime measurement on the monitor.

![Figure 2 Determining the QT Value](image)
**QT Measurements**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>QT</td>
<td>QT interval in milliseconds. The QT interval is defined as the time between the beginning of the Q-wave and the end of the T-wave.</td>
</tr>
<tr>
<td>QTc</td>
<td>The heart rate corrected QT interval. Faster heart rates shorten the QT interval and slower heart rates prolong the QT interval.</td>
</tr>
<tr>
<td>ΔQTc</td>
<td>The delta QTc is the difference between the current QTc value and the QTc baseline value.</td>
</tr>
<tr>
<td>QT-HR</td>
<td>The heart rate used to calculate the QTc value</td>
</tr>
</tbody>
</table>

**QT Adjustment for Heart Rate**

The QT interval has an inverse relationship to heart rate. Faster heart rates shorten the QT interval and slower heart rates prolong the QT interval. Heart rate corrected QT interval is abbreviated as “QTc”. It should be noted that since all correction formulas are population based, they may not be representative for a particular patient. In addition, drugs may also change the relationship between QT and heart rate.

The QTc correction formula can be configured in unit settings to either Bazett or Fredericia. The same formula will be used for the the 12-lead ECG analysis QTc and manual measurements using electronic calipers performed at the Patient Information Center.
Setting up the QT measurement

To start QT Interval Monitoring

1. Select Main Setup.
2. Select Measurements.
3. Select QT Analysis.

 QT Setup Menu

<table>
<thead>
<tr>
<th>Setup QT Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>QT View</td>
<td></td>
</tr>
<tr>
<td>QT Lead</td>
<td>All</td>
</tr>
<tr>
<td>QTc High Limit</td>
<td>500</td>
</tr>
<tr>
<td>ΔQT High Limit</td>
<td>60</td>
</tr>
<tr>
<td>QT High Alarm</td>
<td>On</td>
</tr>
<tr>
<td>ΔQT High Alarm</td>
<td>On</td>
</tr>
<tr>
<td>Set QT Baseline</td>
<td></td>
</tr>
<tr>
<td>QT Analysis</td>
<td>OFF</td>
</tr>
</tbody>
</table>

To switch QT Analysis On

In the Setup QT Analysis menu, select QT Analysis to toggle.

Selecting QT Lead(s)

For QT Monitoring you can select one of the following three modes:

- All Leads mode - all available leads
  - I or II or III or MCL for a 3-leadset
  - I, II, III, V for a 5-leadset
  - I, II, III and two of V leads (V₁ - V₆)
  - I, II, III, V₁ - V₆ for 10-leadset
  - EASI lead placement - AI, AS and ES leads are used.

- Primary-Lead mode - the primary lead will be used for QT measurement.
  If the original primary lead becomes unavailable or is changed, QT measurement will continue with the new primary lead.

- Single-Lead mode - a single lead selected from all available leads (except the augmented leads) will be used for QT measurement. QT measurement will stop if the selected lead becomes unavailable.
To select the lead mode

<table>
<thead>
<tr>
<th>Setup QT Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>QT View</td>
</tr>
<tr>
<td>QT Lead           : All</td>
</tr>
<tr>
<td>QTc High Limit    : 500 Primary</td>
</tr>
<tr>
<td>ΔQT High Limit    : 60 I</td>
</tr>
<tr>
<td>QT High Alarm     : On II</td>
</tr>
<tr>
<td>ΔQT High Alarm    : On III</td>
</tr>
<tr>
<td>Set QT Baseline   : MCL V</td>
</tr>
<tr>
<td>QT Analysis       : OFF V1</td>
</tr>
<tr>
<td>:</td>
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<td>:</td>
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<td>:</td>
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<td>:</td>
</tr>
</tbody>
</table>

1. Select **QT Lead**.
2. Select All, Primary Lead or a specific lead. Select only a lead that is available.

**QT Alarms**

There are two QT alarms

- **QTc high limit alarm**
  - The QTc high limit alarm is generated when the QTc value exceeds the set limit for two 5-minute consecutive values

- **ΔQTc high alarm**
  - The ΔQTc alarm is generated when the difference between the current value and the baseline value exceeds the set limit for two 5-minute consecutive values

**To switch individual QTc Alarms On and Off**

Each QTc alarm can be switched off individually.

1. In the **Setup QT Analysis** menu click select **QTc High Alarm** to toggle the alarm on or off.

**Changing QTc Alarm Limits**

Set the high alarm limits based on your assessment of the patient’s clinical condition, unit protocols, physician orders or medication specified limits.

1. In the **Setup QT Analysis** menu select **QTc High Limit**.
2. Select a value. Values range from 200 - 800 msec increments of 10 msec
QT View

In the QT View window you view the current and baseline ECG snippets for each valid lead used in the QT measurement. This window will assist you in assessing the measurements and troubleshooting problems with the measurement.

All Lead Mode

The current waves are shown in the upper half of the window and the baseline waves in a different color below. The Q and T points are marked with a vertical line. By selecting one of the lead labels at the top of the window you can highlight the corresponding wave; the other waves are shown in gray. The underlined lead labels are the leads used for the QT calculation. By selecting the numeric area you can highlight all underlined leads.
QT View Window Popup Keys

![Image of QT view window]

**Changing The View To A Single Wave Set**

To view one set of waves in a larger scale, you can cycle through the different views,

1. Select **Current** View to see the set of current waves.
2. Select **Baseline** View to see the set of baseline waves.
3. Select **Split** View to return to the combined view with current and baseline waves.

**Setting the Baseline**

In order to quantify changes in the QTc value, you can set a QTc baseline. For example to assess the effect of medication on the QT interval you can set the current value as the baseline before you begin medication. This baseline will then be used to calculate the ΔQTc value.

1. Navigate to the **QT View** and select **Set Baseline** popup key.
2. Select Confirm. The baseline will be set to the current value and ECG snippet.

If no baseline has been set for this patient, the first five minute value after the start of monitoring is automatically set as baseline.

If you set a new baseline the previous baseline is discarded. As the ΔQTc alarm is based on the difference between the baseline and the current value, setting an inappropriate new baseline may prevent a ΔQTc alarm from being generated.

Discharging a patient clears the QT baseline.
Printing The QT Waves
To start a printout,
– Select Print QT.

Recording The QT Waves
To start a recording,
– Select Record QT.
The CANNOT ANALYZE QT INOP and the ? will be displayed when no QT measurement could be calculated for 10 minutes. Up to this time the previous valid value will be displayed. The following additional messages on the cause of the invalid measurements may also be displayed in the QT View window.

<table>
<thead>
<tr>
<th>Additional Messages</th>
<th>Cause of Invalid QT Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>QT Startup</td>
<td>QT monitoring was just turned on or has been reset</td>
</tr>
<tr>
<td>Leads Off or Asystole</td>
<td>Not all specified leads needed to perform QT analysis are available, or Asystole condition is detected</td>
</tr>
<tr>
<td>Insufficient Valid Leads</td>
<td>Not enough valid QRS complexes to generate a QT measurement</td>
</tr>
<tr>
<td>Invalid rhythm for QTc</td>
<td>Not enough valid RR intervals to generate QT-HR, the averaged HR used for QTc calculation</td>
</tr>
<tr>
<td>High QT-HR</td>
<td>QT-HR exceeds the specified upper limit of 150 bpm (for adults) or 180 bpm (for neonates and pediatrics)</td>
</tr>
<tr>
<td>Small R Wave</td>
<td>R-wave of the signal is too small</td>
</tr>
<tr>
<td>Small T Wave</td>
<td>T-wave of the signal is too small</td>
</tr>
<tr>
<td>End of T Not detected</td>
<td>End of the T-Wave cannot be accurately detected</td>
</tr>
<tr>
<td>QT Out Of Range</td>
<td>QT measurement is outside the specified range of valid QT values (200 - 800 msec)</td>
</tr>
<tr>
<td>QTc Out Of Range</td>
<td>QTc measurement is outside the specified range of valid QTc values (200 - 800 msec)</td>
</tr>
<tr>
<td>QTc Erratic</td>
<td>QTc measurements are not stable</td>
</tr>
</tbody>
</table>
QT Measurement Limitations

Under the following conditions it may be difficult to achieve reliable QT monitoring and may produce a “Cannot Analyze QT” INOP message.

During QT startup period, this INOP is announced immediately when QT value is invalid. After startup, this INOP is announced after the QT measurement is invalid for >10 minutes.

T-wave detection limitations
To accurately measure the QT interval, the algorithm must determine the beginning of the QRS and the end of the T-wave. The following conditions will make it difficult to determine the end of the T-wave.

- Flat T-wave
- Atrial Fibrillation or Atrial Flutter
- Prominent U-waves

In cases where the QT cannot be measured reliably, one should select a single lead with a good T-wave amplitude and no visible fibrillatory or flutter activity, and without a predominant U-wave or P-wave.

QRS Changes
Increases in QRS duration contribute to a long QTc interval.

- Widened QRS

In this case, if a long QTc is observed you should verify it to ensure that it is not caused by QRS widening.

Rhythm and rate limitations

- High heart rate
  When the heart rate is high, the P wave of the subsequent P-QRS-T complex may approach the end of the T wave and produce an effect similar to that of a U wave.
  - Heart rate > 150 beats/min for adults patients
  - Heart rate > 180 beats/min for pediatric or neonatal patients.

- Paced Rhythm
  Ventricularly Paced or AV sequentially paced rhythm produced widened QRS

- Bigeminy Rhythm
  May produce a longer QT interval due to widened QRS on every other beat.

In these cases, if rhythm is sustained you may consider turning QT Interval monitoring off.

Continuous measured versus manually measured QT parameters
Manually measured QT parameters performed using the Information Center E-calipers may differ from continuously measured parameters. The values reported on the strip are updated every five minutes and when the signal is noisy may be displayed for 10 minutes.
**Test**

1. Which of the following shows the measure points for the QT interval?
   - a. 1
   - b. 2
   - c. 3
   - d. 4

2. QT/QTc Interval monitoring can be performed on the patient with 1:1 ventricular pacing. (circle one)
   - a. True
   - b. False

3. Which of the following are indications for QT/QTc interval monitoring
   - a. Patients administered an antiarrhythmic drug known to cause Torsade de Pointes
   - b. Patients with new onset bradyarrhythmia
   - c. Patients with severe hypokalamaia
   - d. All of the above
4. QT/QTc measurements are displayed and trended in:
   a. seconds
   b. millimeters
   c. milliseconds

5. The QTc is:
   a. A heart rate corrected QT interval measurement using Fredericia's formula.
   b. A heart rate corrected QT interval measurement using Bazett's formula.
   c. A heart rate corrected QT interval measurement using either Bazett’s formula or Fredericia formula depending on your unit setting.

6. The QT Setup menu allows the user to:
   a. Turn QT Interval monitoring on/off.
   b. Allows you turn off individual QTc alarms.
   c. Navigate to the QT View to see QT waveforms and values.
   d. Adjust the QTc High and dQTc High alarms.
   e. All of the above

7. QT lead selection allows the user to:
   a. Select all leads
   b. Primary or Secondary Lead
   c. A single lead
   d. All of the above

8. The following alarms are available for QT:
   a. QT, QTc, dQT high
   b. QT, QTc, dQT high and low
   c. QTc and dQT high
   d. QTc and dQT high and low

9. The QT measurements are updated:
   a. Every 1 minutes
   b. Every 5 minutes
   c. Every 10 minutes

10. The “Cannot Analyze QT” INOP alarm will be displayed when the QT measurement cannot be measured for 10 minutes up until this time the previous valid measurement will be displayed.
    a. True
    b. False
Knowledge Test Answers

1 4

2 False

3 d

4 c

5 c

6 e

7 d

8 c

9 b

10 a