



12-Lead ECG For Monitoring and Diagnostic Use Application Note

For IntelliVue Patient Monitors Rev. J.xx.xx and
IntelliVue Information Center iX Rev. A.xx.xx

About This Paper

The goal of this application note is to support the clinician in the proper use of the 12-Lead ECGs modalities provided by IntelliVue Patient Monitors and IntelliVue Information Center iX.

The application note:

- Describes the system capability and its components.
- Explains how to acquire a 12-Lead ECG.
- Reviews the conventional 12-Lead electrode placement and describes how to check that the electrodes are correctly placed.
- Reviews the modified electrode placement (Mason-Likar) and summarizes its benefits and limitations.
- Discusses signal quality and filter use.
- Explains common problems seen in waveforms for both conventional and modified electrode placement.
- Explains the format of 12-Lead ECG reports.

Introduction

Philips provides a comprehensive ECG solution to meet both the diagnostic and monitoring needs of patients in critical care. In addition to the standard 3 or 5-lead monitoring, there are three types of 12-Lead ECGs: directly acquired using a 10-electrode cable set, Hexad partially derived from 6-electrode cable set or EASI fully derived from a 5-electrode cable set.

This solution offers both continuous 12-Lead ECG monitoring and diagnostic 12-Lead ECG capture at the Patient Monitor. The 10 seconds of captured 12-Lead ECG is analyzed using the Philips 12-Lead Analysis Algorithm at the Information Center iX. For the directly acquired 12-Lead ECG, the time-based interval measurements, axis measurements and the interpretation statements are provided. For the EASI and Hexad derived 12-Lead ECG only the time-based interval measurements are provided. The captured 12-Lead ECGs can be reviewed at the Information Center iX as well as at the Patient Monitor.

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12-Lead ECG at the IntelliVue Patient Monitor

At the IntelliVue Patient Monitor, 12 leads of ECG can be viewed, recorded or printed. In addition, any two of the 12 leads of ECG can be selected for multi-lead arrhythmia analysis and all 12 leads of ECG can be used for ST segment analysis.

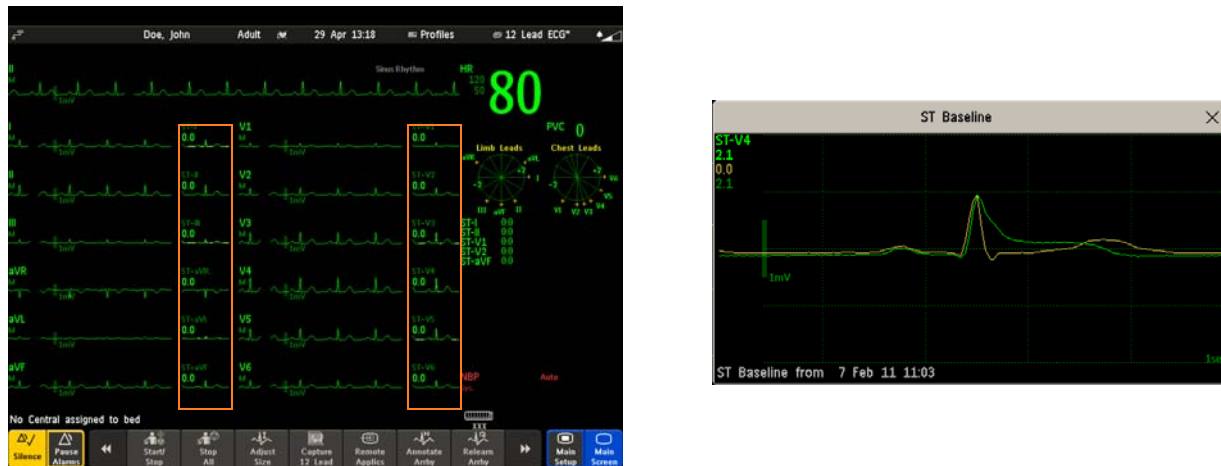


Figure 1: 12-Lead ECG Screen with ST Snippets and ST Map

At the Patient Monitor, the user can review the 12-Lead ECG prior to sending it to the Information Center iX for analysis (Release J.0x.xx and higher). The 12-Lead ECG Application window allows the user to capture 10 seconds of ECG data, print a diagnostic ECG report, send the data to the Information Center iX, and store the data locally at the IntelliVue Patient Monitor.

The captured 12-Lead ECGs at the Patient Monitor can be viewed or printed with different filters, speeds and layouts. When stored and sent, the Information Center iX receives 10 seconds of ECG waveforms at 0.05-150 Hz at 500 samples/second and the settings for filters, speeds and layouts. When received by the Information Center iX, the 12-lead ECG is analyzed and the results of the analysis are sent back to the Patient Monitor for review by the clinician.



Figure 2: IntelliVue Patient Monitor with 12-lead ECG Application Window open displaying a captured 12-lead Preview

12-Lead ECG at the Information Center iX

At the IntelliVue Information Center iX, the captured 12-Lead ECG can be viewed by selecting the 12-Lead Review button from the Patient Window after completion of the ECG analysis. The Information Center iX can store up to 30 captured 12-Lead ECGs.

In addition, the Information Center iX has the capability of 24 hours 12-lead ECG full disclosure if EASI lead placement is used at the Patient Monitor or with a telemetry transmitter. All 12-lead ECGs stored at the Information Center iX can be viewed at the Patient Monitor for review by the clinician.

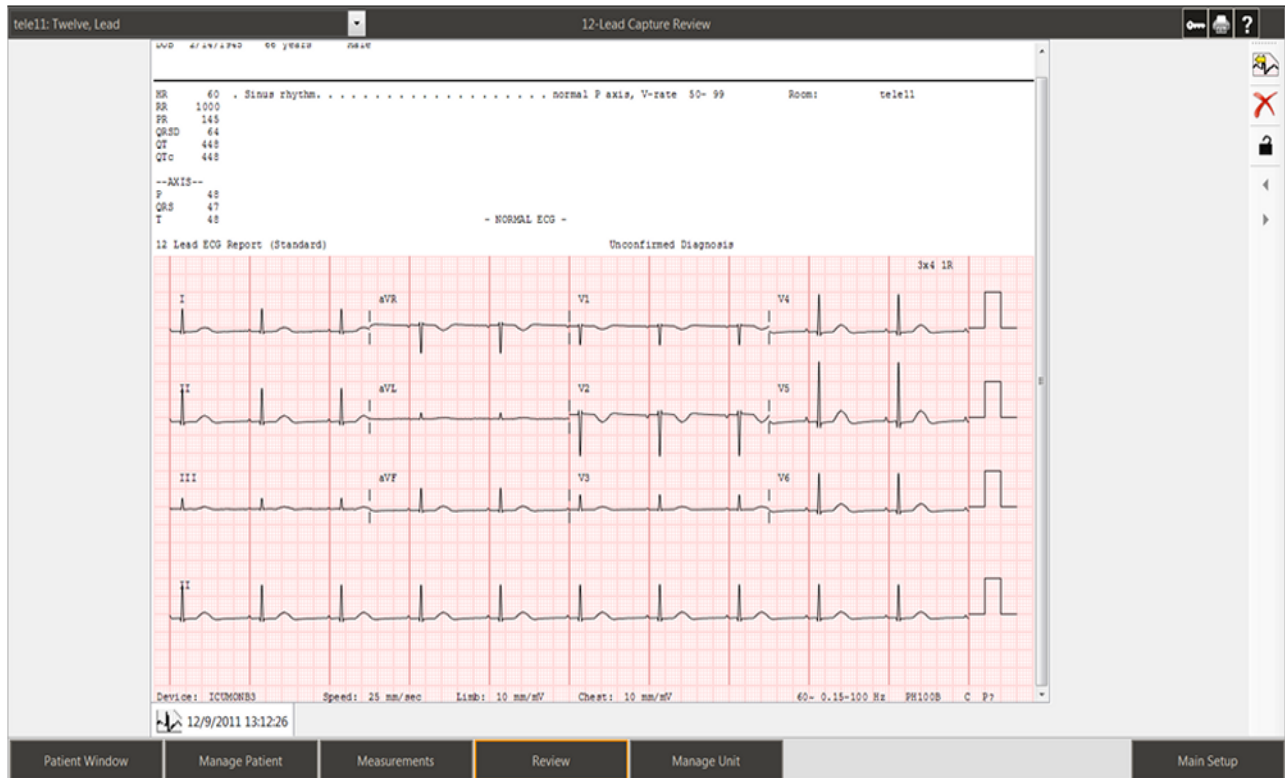


Figure 3: Information Center iX 12-Lead Review window displaying a captured 12-Lead ECG from the Patient Monitor

Obtaining 12-Lead ECGs

Figure 4 demonstrates how 12-Lead ECGs are obtained and transmitted across the monitoring system. Traditionally, diagnostic 12-lead ECGs are acquired using a cardiograph. The cardiograph uses a 12-Lead interpretation algorithm to analyze the ECG waveforms.

The IntelliVue Patient Monitor provides the capability of monitoring up to 12-leads of ECG.

When the Capture 12 Lead Smartkey or Capture 12 Lead entry from the patient monitor's Main Setup menu are selected, at the Patient Monitor, the 12-Lead ECG Application window is opened and up to 12 leads of ECG are displayed. The user can capture 10 seconds of waveform in a preview window prior to sending the data to the

Information Center iX. Selecting **Store & Send** saves the 12-Lead at the bedside monitor and sends 10 seconds of the diagnostic waveform to the Information Center iX. At the Information Center iX, the diagnostic 12-Lead ECG waveform is analyzed and stored. The Information Center iX can save up to 30 12-lead ECGs. The Information Center iX uses the same 12-Lead interpretation algorithm as the Philips PageWriter TC series cardiographs with the DXL (PH100B) algorithm. The analyzed 12-lead ECG is sent back to the IntelliVue Monitor for review. The 12-Lead ECG can then be reviewed, printed and/or exported to TraceMasterVue or an alternative ECG management system for storage and validation by a qualified clinician.

12-Lead ECG Data Flow in the IntelliVue Monitoring System

The following figure provides an overview of the flow of 12-Lead ECG data in the IntelliVue Monitoring System:

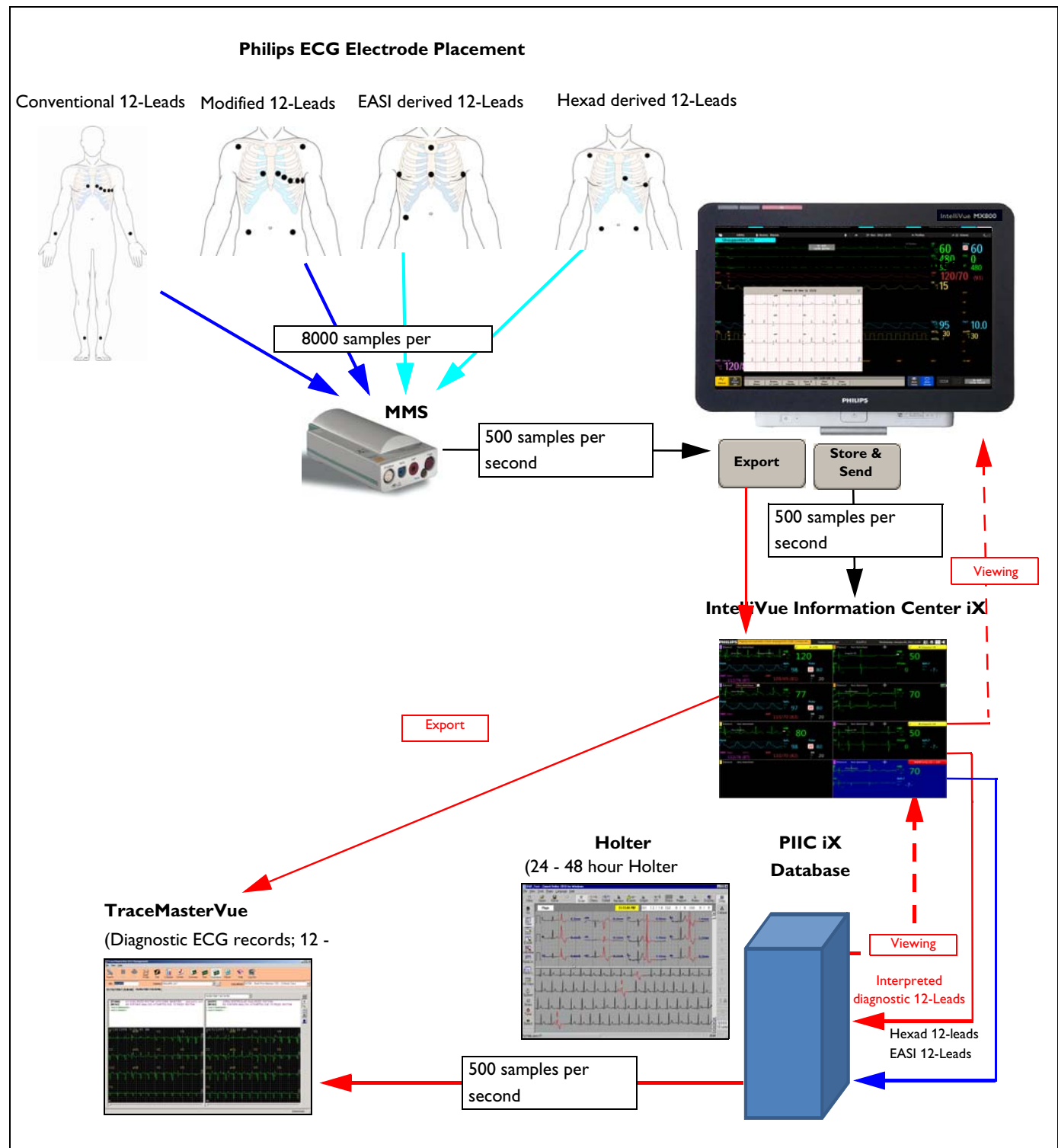


Figure 4: 12-Lead ECG Data Flow

12-Lead ECG Electrode Placement

Conventional Lead Placement

Limb Electrodes

- Place arm electrodes on the inside of each arm, between the wrist and the elbow.
- Place leg electrodes inside of each calf, between the knee and the ankle.
- To minimize muscle artifact, place the electrodes on the fleshy part of the limb, avoiding large bones and muscles.

Note: Bone is a poorer conductor but may produce less muscle interference. Muscle is a better conductor but may produce more interference.

Chest Electrodes

Table 1 lists the placement of the chest (precordial) electrodes. Place them in the following order:

- V1, V2, V4
- V3
- V6
- V5

Electrode	Position
V1	on the 4 th intercostal space at the right sternal border
V2	on the 4 th intercostal space at the left sternal border
V3	midway between the V2 and V4 electrode positions
V4	on the 5 th intercostal space at the left midclavicular line
V5	on the left anterior axillary line, horizontal with the V4 electrode position
V6	on the left midaxillary line, horizontal with the V4 electrode position

Table 1: Placement of Chest Electrodes

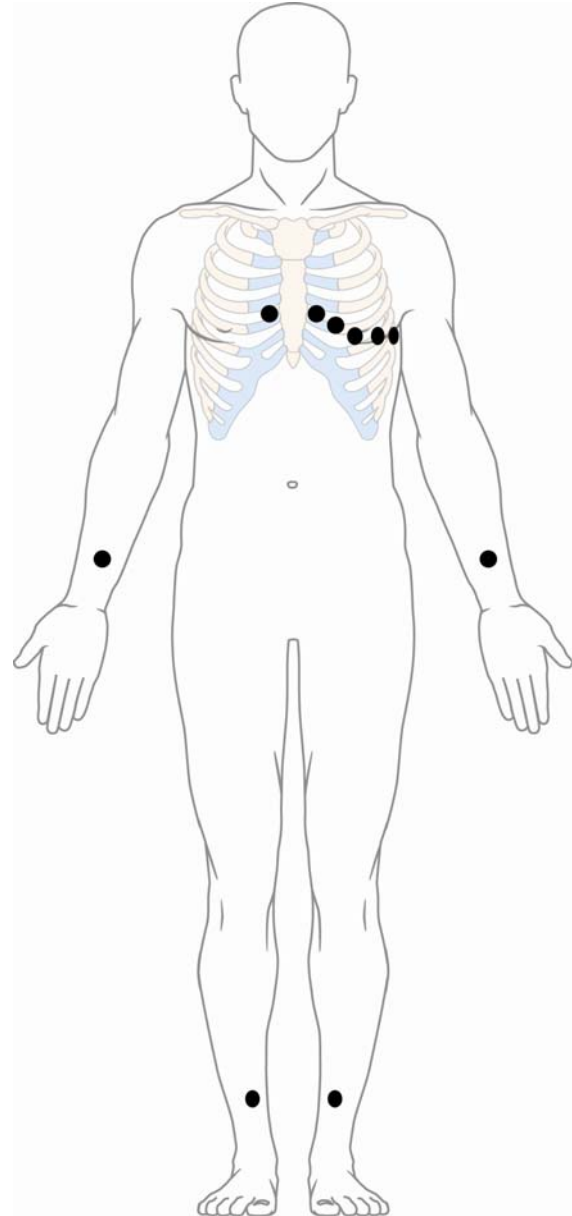


Figure 5: Conventional 12-Lead ECG Placement

Modified Lead Placement (Mason-Likar)

- In the modified (Mason-Likar) electrode configuration, the limb electrodes are placed on the torso in the same locations as used for standard continuous ECG monitoring.
- The arm electrodes are placed below the clavicle near the shoulders.
- The leg electrodes are placed on the lower abdomen.
- The chest (precordial) electrodes are placed in the same positions as conventional 12-Lead ECG placement.

As with conventional 12-Lead ECG placement, accurate electrode placement is required for quality 12-Lead ECG measurements.

This lead placement should not be used for diagnostic interpretation using the Philips 12-Lead ECG Algorithm.

Advantages of Modified Electrode Placement

One advantage of the Mason-Likar configuration is that it is less susceptible to movement artifact than the conventional 12-Lead ECG placement (because the limb electrodes are on the torso).

Also, because the electrodes are on the torso, the modified placement is more comfortable for the patient than the conventional placement.

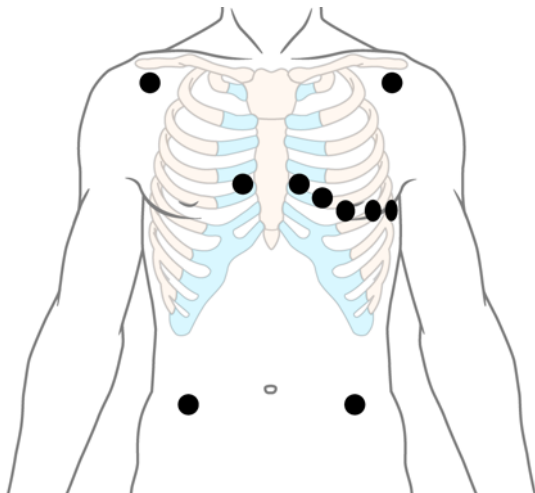


Figure 6: Modified Lead Placement (Mason-Likar)

Hexad 12-Lead Placement using 6-wire lead set

Hexad lead placement is available for MX40 telemetry with a 6-wire lead set and can be selected at the Information Center iX in the Telemetry Setup window. To use Hexad derivation, select the pair of chest leads where the Va and Vb electrodes will be placed. The Hexad algorithm will derive the four additional leads.

Telemetry Setup		
Telemetry Button	Nurse Call	
Find		
Wave 1	Primary Lead	
Wave 2	Secondary Lead	
Wave 3	ECG	
Wave 4	ECG	
Hexad (Va,Vb)	Off	
		Hexad (Va,Vb)
		☒ Off
		V1,V3
		V1,V4
		V1,V5
		V2,V4
		V2,V5
		V3,V5
		V3,V6

Figure 7: Telemetry Setup Window on Information Center iX

The label **Hexad** is shown beside the 1 mV calibration bar on the ECG wave on the display, and **Hexad** derived leads are marked on any recorder strip and printout.

Electrodes are placed in Mason-Likar limb position with two chest leads placed in standard position.

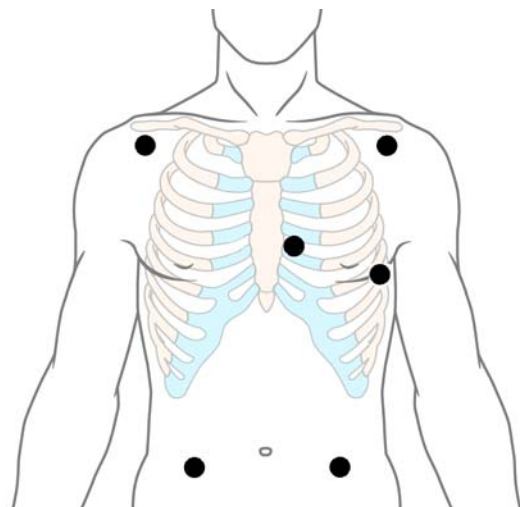


Figure 8: 6-Electrode Lead Placement with V2 and V4

EASI™ Lead Placement

EASI monitoring is available on all IntelliVue Patient Monitors. To monitor with EASI lead placement, you must enable **EASI** in the Setup ECG menu under **Lead Placement**.

EASI derived 12-Lead ECGs and their measurements are approximations to conventional 12-Lead ECGs and should not be used for diagnostic interpretations.

- The Label **EASI** is shown beside the 1 mV calibration bar on the ECG wave on the display, and **EASI** is marked on any recorder strip and printout.

Electrode	Position
E	on the lower sternum at the level of the 5 th intercostal space
A	on the left midaxillary line at the same level as the E electrode
S	on the upper sternum
I	on the right midaxillary line at the same level as the E electrode
Ref	reference electrode - can be anywhere, usually below the 6 th rib on the right hip

Table 2: Placement of EASI Electrodes

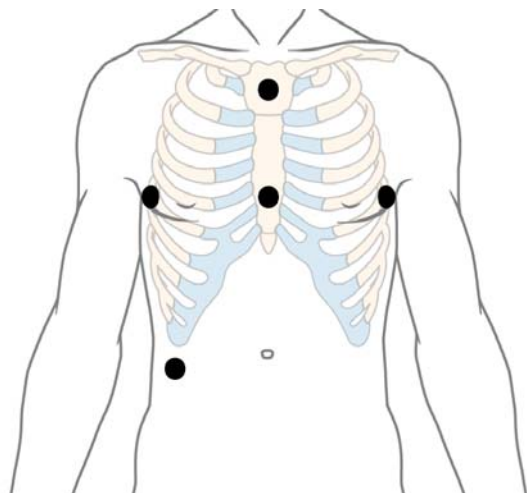


Figure 7: EASI Lead Placement

Differences between Conventional and Modified Electrode Placement

To properly record a 12-Lead ECG, it is important to have the patient lying comfortably with the wrist close to but not touching the torso. The limb electrodes should be placed on the right and left wrists and the right and left ankle. The outer aspect of the wrist should be used to ensure that the arm does not need to be rotated. The leg electrodes should be placed on the outer aspect of each ankle.

In continuous 12-Lead ECG monitoring, electrodes placed in conventional lead placement, may cause excessive noise due to muscle activity and electrode artifact due to electrode movement. The signal noise caused by muscle activity can be reduced by placing the electrodes on the shoulders and hips instead of the wrists and ankle as suggested by R. E. Mason and I. Likar in 1966. The Mason-Likar modification of the 12-Lead ECG system is used in exercise ECG and continuous Patient Monitor monitoring of the 12-Lead ECG.

If the limb electrodes are placed on the torso (Mason-Likar Placement), the recording will be different from that obtained using the conventional electrode placement (see figure 9). These variations include a rightward shift of the mean QRS axis due to a reduction in R wave amplitude in I and aVL, and increase in R wave in Lead II, III and aVF. Chest leads are also affected because of the altered potential of the central terminal.

There are occasions when limb electrodes need to be shifted to obtain 12-Lead ECGs. For example, a cast on a limb, a partially or entirely missing limb, or to minimize noise in the ECG signal.

Any change in electrode placement from the conventional electrode placement must be clearly noted on the ECG recording or printout. The IntelliVue Patient Monitors allows the user to mark the printouts and captured 12-Leads ECGs as a modified lead placement. In the ECG setup window, setting **Mod.LeadPlacement** to **On**, will label all 12-Lead ECG reports and captured 12-Lead ECGs from the Patient Monitor to the Information Center iX as Mason-Likar (see figure 9).

Be sure to mark ECGs as modified (Mason-Likar) to prevent misdiagnosis and use caution when comparing 12-Lead ECGs acquired using different electrode placements.

The 12-Lead ECGs displayed on the following page demonstrate the changes that occur when placing the limb electrodes in different positions. Both 12-Lead ECGs were obtained from the same individual.

In figure 8, the limb electrodes were placed on the outer aspect of the wrist and ankles. In figure 9, the limb electrodes were moved to the torso which is typically the position of the limb electrodes during continuous monitoring. This 12-Lead ECG shows significant changes in the limb leads particularly in Leads II, III and aVF. The P-wave, QRS and T-wave axis measurements also demonstrate large differences from the 12-Lead ECG performed with the limb electrodes on the wrists/ arms and ankles/leg. In addition, the 12-Lead ECG interpretative

algorithm based on these measurements interpreted this 12-Lead ECG as a “borderline right axis deviation.”

These differences that the modified lead placement creates may lead to misdiagnosis and may mask inferior infarction due to calculated axis, R-, P-, and T-wave magnitudes shifts, and ST slope.

Examples of Lead Placement

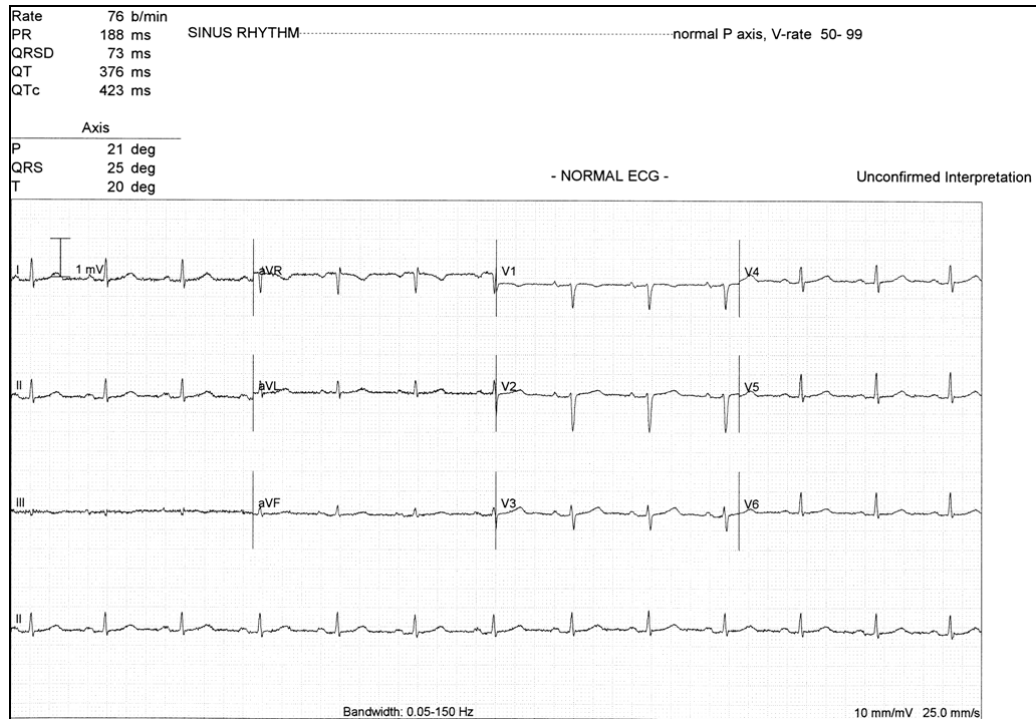


Figure 8: Conventional Lead Placement - Limb electrodes on the wrists and the ankles

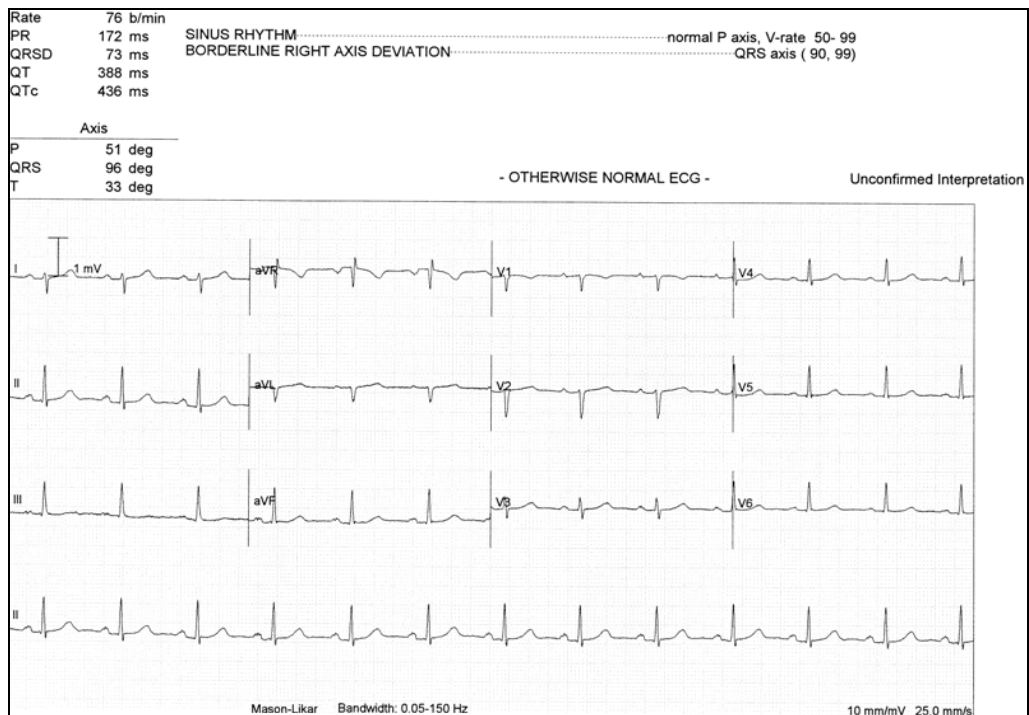
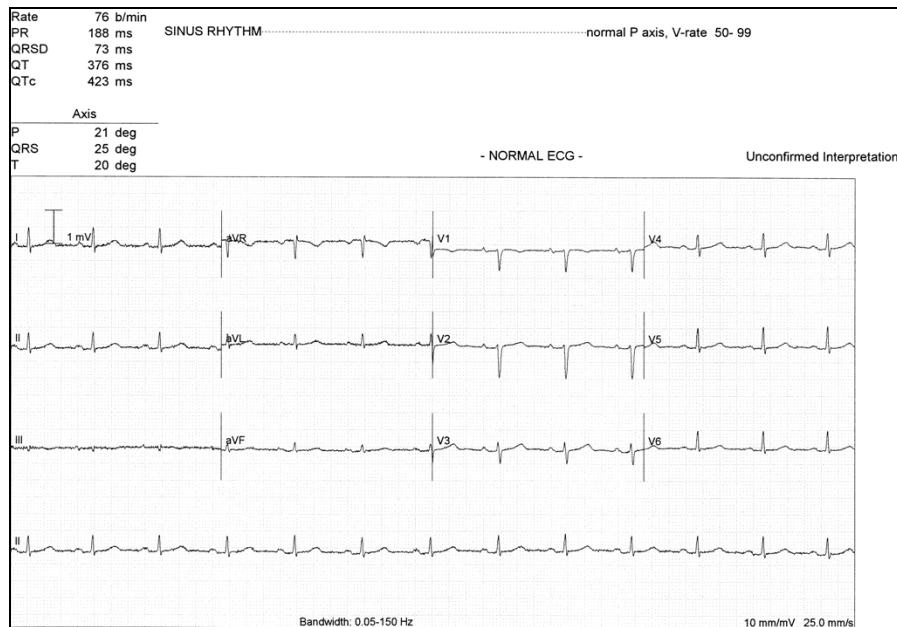


Figure 9: Modified Lead Placement (Mason-Likar)

Checking for Correct Placement

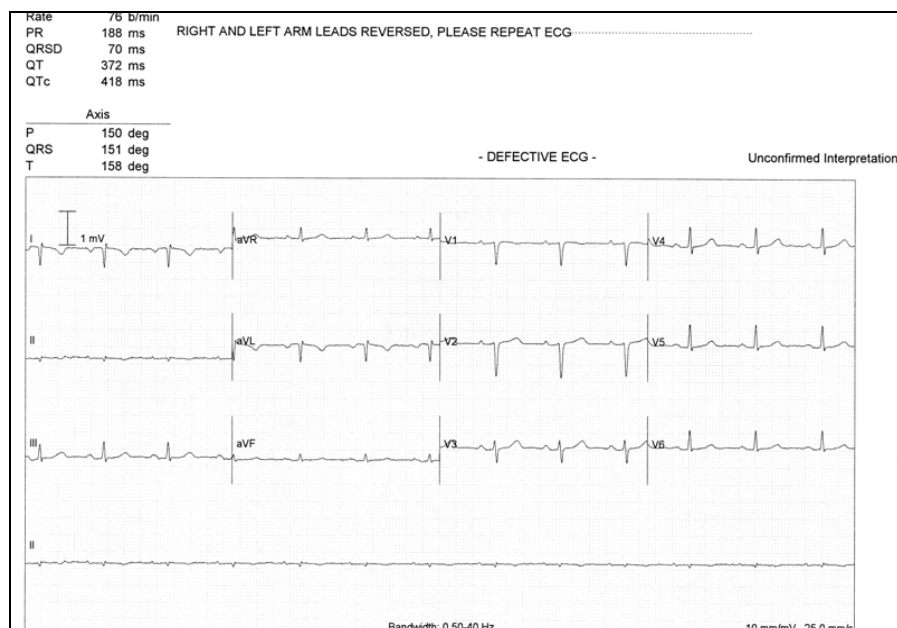
To ensure quality 12-Lead ECG monitoring, it is important to check that the electrodes are correctly placed.



If they are, you should see these landmarks:

- Positive P-wave in Lead II.
- Negative QRS in Lead aVR.
- R-wave progression in the precordial leads.
- Normal R-wave progression is as follows:
 - Negative R-wave in Lead V1 and Lead V2.
 - Biphasic R-wave in Lead V3.
 - Positive R-wave in Lead V4 - Lead V6.

Figure 10: Correct Lead Placement



In this figure, the right and left arm electrodes have been reversed - all other lead placement is correct.

- By noting that aVR is positive, the 12-Lead ECG analysis algorithm was able to detect this error and alert the clinician to repeat the 12-Lead ECG.

Figure 11: Incorrect Lead Placement - Reversed right and left arm electrodes

Signal Processing

The ECG signal at the body surface is transmitted via the ECG leadset and cable. The ECG measurement device then digitizes the analog signal at a sample rate of 500 samples per second in the frequency range of 0.05 Hz to 150 Hz.

Filter Settings Used for Real-time ECG Monitor at the Patient Monitor

These filters suppress ECG signals at the high and low frequency range to allow the user to view a clearer ECG signal when noise is present.

The following table lists the different bandwidths that result from applying the different filter modes available in the IntelliVue Patient Monitors.

Patient Category	Filter Mode	Bandwidth
Adult	Diagnostic	0.05 Hz - 150 Hz
	Extended Monitoring	0.5 Hz - 150 Hz
	Monitoring	0.5 Hz - 40 Hz
	Filter	0.5 Hz - 20 Hz
Pediatric/Neonatal	Diagnostic	0.05 Hz - 150 Hz
	Extended Monitoring	0.5 Hz - 150 Hz
	Monitoring	0.5 Hz - 55 Hz
	Filter	0.5 Hz - 20 Hz

Table 3: Filter Settings

- For adult patients, use the Diagnostic Filter Mode to obtain an ECG signal with the highest fidelity for viewing and recording.
- For pediatric or neonatal patients, consider using the Extended Monitoring Filter Mode to reduce motion artifacts.

Using Filters

There is a trade off between clarity and fidelity of the ECG trace when a filter is applied. The more filtering applied, the greater the possibility of removing ECG signal details.

Changing the high frequency filter to 20 Hz, 40 Hz or 55 Hz results in a smoother looking ECG waveform while eliminating some fine detail in the signal. Small deflection, notches, slurs may be distorted or may disappear if one of these filters is applied.

Changing the low frequency filter to 0.5 Hz can be used to reduce baseline noise such as baseline wander. Baseline wander is the slow (typically 0.1 Hz - 0.2 Hz) drifting of the ECG baseline up or down.

Baseline wander may result from patient respiration or from other sources such as dried electrodes. Severe baseline wander may make it difficult to determine the true wave shapes in the ECG.

Changing the low frequency filter to 0.5 Hz might result in distortion of the ST segment in real-time ECG waves.

Real-time ECG waves are used on the Patient Monitor's main screen and the Information Center iX's patient sector, on strip recordings, and on the real-time ECG reports (**ECG Report A/B**).

Diagnostic 12-Lead ECGs shown on and printed from the 12-Lead ECG application at the Patient Monitor and the Information Center iX will not result in ST segment distortion, regardless of the filter mode settings.

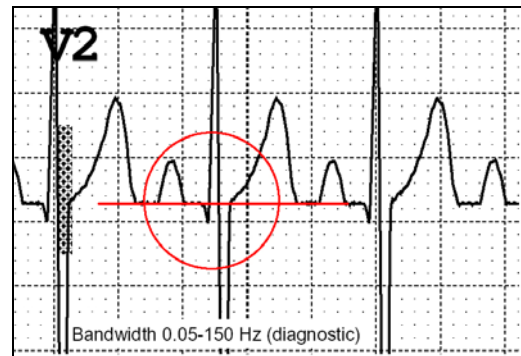


Figure 12: Diagnostic Mode 0.05 Hz: No ST distortion

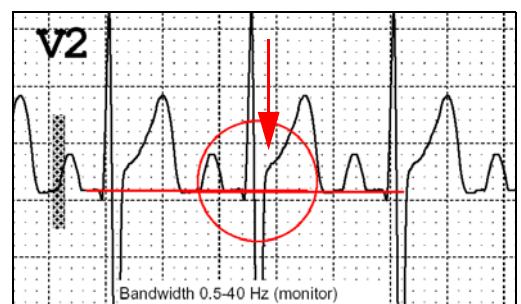


Figure 13: Monitor Mode 0.5 Hz: ST distortion

Filter settings used for ST Segment Analysis

The ST/AR ST analysis algorithm receives the ECG signal at the highest fidelity 0.05 Hz regardless of the patient category or filter mode setting. ST/AR applies a special 0.67 Hz filter for analysis. This filter type does not distort the ST segments.

The ST waveforms captured by the ST/AR analysis algorithm can be used for assessment of ST segment changes (figure 14). The ST waveforms can be displayed at the Patient Monitor as well as recorded. The ST waveforms are also stored at the Information Center iX for the ST Review application.

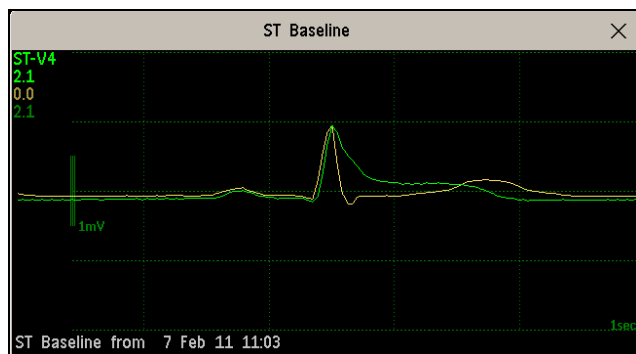


Figure 14: ST snippets available on the IntelliVue Patient Monitor can be used for assessment

Filters used for 12-Lead ECG Application

The 12-Lead ECG signal sent from the Patient Monitor is at a sample rate of 500 samples per second in the frequency range 0.05 Hz to 150 Hz. This signal is used for the 12-Lead ECG analysis performed by the Philips 12-Lead ECG Algorithm.

For viewing and printing, when the 12-Lead ECG is sent to the Information Center iX the filter settings from the bedside are sent and will be viewed and printed using these settings. After capture the settings may be changed at either the IntelliVue Patient Monitor or at the Information Center iX. The changes, however, are local to the device.

The type of filter used by cardiographs and the 12-Lead ECG Application is a filter that does not cause distortion of the ST segment when using 0.5 Hz filter. However it requires delayed processing and cannot be used when real-time viewing and recording is required.

**IntelliVue Patient Monitor
Real-time ECG Monitoring**

Patient Category	Filter Mode	Bandwidth Realtime Waves
Adult	Diagnostic	0.05 - 150 Hz
	Extended Monitor	0.5 - 150 Hz
	Monitor	0.5 - 40 Hz
	Filter	0.5 - 20 Hz
Pediatric/ Neonatal	Diagnostic	0.05 - 150 Hz
	Extended Monitor	0.5 - 150 Hz
	Monitor	0.5 - 55 Hz
	Filter	0.5 - 20 Hz

**12-Lead ECG Application for IPM and PIIC iX
12-Lead ECG/Review Application**

Bandwidth for 12-Lead ECG	High Pass Filter	Low Pass Filter	AC Filter
Diagnostic	0.05 Hz	150 Hz	On/off
	0.15 Hz	100 Hz	On/Off
Monitoring	0.5 Hz	40 Hz	On/Off
		20 Hz (PIIC iX only)	On/Off

**Phillips Information Center iX
Real-time Monitoring**

Patient Category	Filter Mode	Bandwidth Realtime Waves
Adult	Diagnostic	0.05 - 150 Hz
	Extended Monitor	n/a
	Monitor	0.5 - 40 Hz
	Filter	0.5 - 20 Hz
Pediatric/ Neonatal	Diagnostic	0.05 - 150 Hz
	Extended Monitor	0.5 - 150 Hz
	Monitor	0.5 - 55 Hz
	Filter	0.5 - 20 Hz

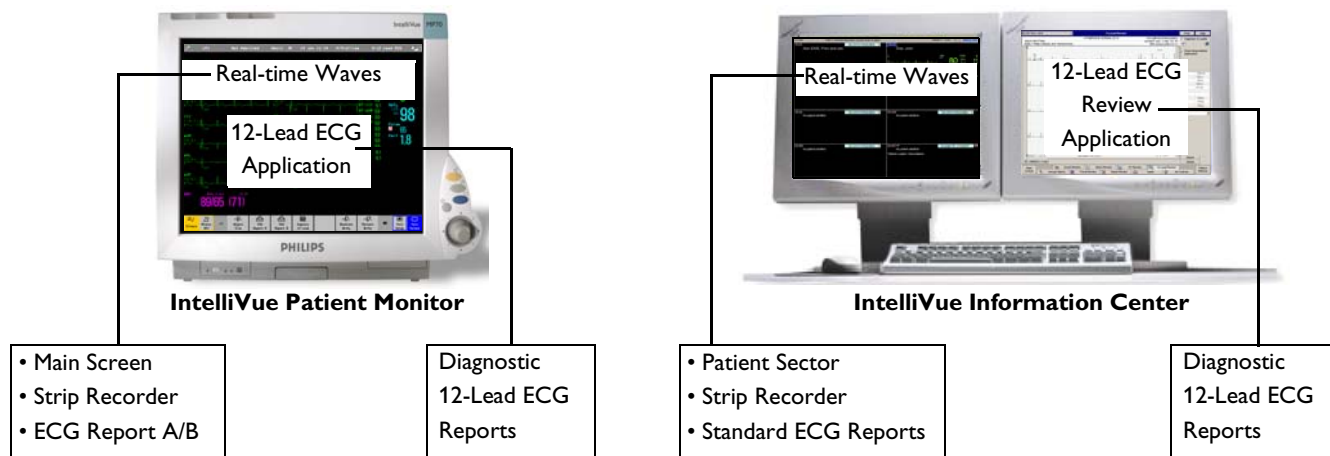


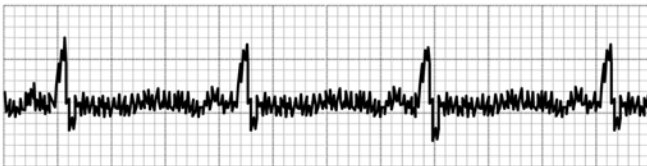
Figure 15: Filters used for 12-Lead ECGs

Common 12-Lead ECG Monitoring Problems

Obtaining a 12-Lead ECG with computer-assisted ECG analysis begins by obtaining accurate and noise-free ECG waveforms. Improving the electrode to skin interface by preparing the skin and using fresh electrodes helps eliminate most noise quality problems.

This section describes common problems that can be encountered when using both conventional and modified electrode placement.

Electrical Interference

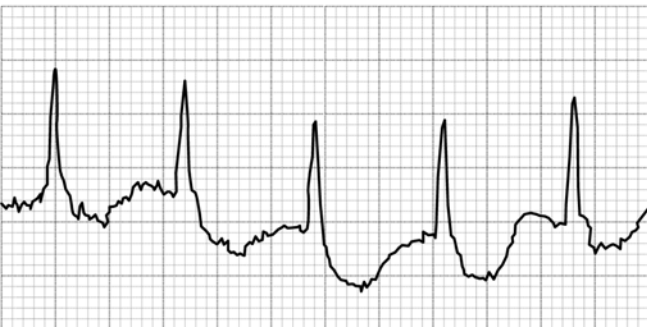


Possible cause: Presence nearby from an electrical device (e.g., IV pump, microwave oven, cellular phone).

Solution: Check the environment for possible electrical devices that can cause interference and unplug if possible or switch the device to battery power.

Figure 16: Electrical Interference

Wandering Baseline

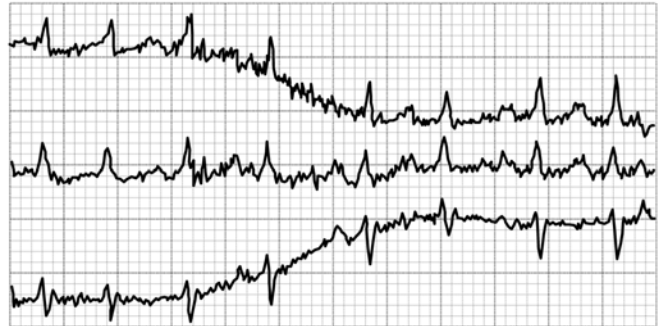


Possible cause: Patient movement, respirations, dry electrodes or loose electrode.

Solution: Instruct the patient to lie quietly. Apply fresh electrodes

Figure 17: Wandering Baseline

Somatic Tremors



Possible cause: Involuntary movement (shivering).

Solution: Warm/cover the patient and assist with limiting patient movement.

Figure 18: Somatic Tremors

Loose Electrode



Possible cause: Electrode is not adhering adequately to the skin.

Solution: Check electrodes and re-apply if needed.

Figure 19: Loose Electrode

The Philips 12-Lead ECG Analysis Algorithm

For the conventional 12-Lead ECG waveforms provided by the IntelliVue Patient Monitor, the Philips 12-Lead ECG algorithm provides an analysis of the amplitudes, durations and morphologies of the ECG waveforms and the associated rhythm. For the Hexad 12-Lead ECG and the EASI 12-Lead ECG, the Philips 12-Lead ECG algorithm provides only time-based interval measurements. The ECG analysis is based on standard criteria for interpretation of these parameters, calculation of the electrical axis and the relationship between leads. The 12-Lead analysis algorithm is highly age and gender specific. Patient age and gender are used throughout the program to define normal limits for heart rate, axis deviation, time intervals, and voltage values for interpretation accuracy in tachycardia, bradycardia,

prolongation or shortening of PR and QT intervals, hypertrophy, early repolarization, and myocardial infarction.

Adult criteria apply if the patient age entered is 16 years old or older or if no age is specified. Pediatric criteria apply if the patient age entered is younger than 16 years of age.

Keep in mind that a computer-interpreted ECG report is not intended to be a substitute for interpretation by a qualified clinician. The interpreted ECG is a tool to assist the clinician in making a clinical diagnosis in conjunction with the clinician's knowledge of the patient, the results of physical examination, and other findings. The algorithm helps to identify problem areas for the clinician and saves time for the clinician or editing technician who may need only to add, delete or modify a few statements.

The 12-Lead ECG Analysis Algorithm Process

The following is a brief review of the Philips 12-Lead ECG Algorithm. For a detailed description of the 12-Lead ECG Algorithm, review the *Philips 12-Lead Algorithm Physician's Guide* (Part number 4535 641 06411).

Step 1: Signal Quality Check

The algorithm examines the signal quality of each ECG Lead to ensure that good ECG measurements can be made. The ECG is analyzed for muscle artifact, AC noise, baseline wander, and leads off. In addition, a check for correct placement of right arm and left arm leads is also performed. Any problems that are not corrected by the operator are described in the interpretative statements on the ECG report.

Step 2: Waveform Recognition

This step involves beat detection and waveform recognition. If paced mode is on, pacing spikes detected at the Patient Monitor are used for analysis. Pacer spikes are then removed and the resulting waveforms are analyzed with a boundary indicator derived from all leads. Subsequently approximate P wave, QRS complex and T wave regions are then determined for each beat in the ECG.

Step 3: Measurements

Once the final onsets and offsets are determined, the amplitude, duration, area and shape are calculated for every P-wave, QRS complex, ST segment and T-wave in each lead. Waveform irregularities such as notches, slurs, delta waves and pacemaker spikes are also noted for every beat. Measurements for each of the 12 leads are calculated from the predominant beat type. Only if all beats in the

ECG are classified as ventricularly paced will the measurements be performed on the paced beats. If an ECG contains both paced and non-paced beats, only non-paced beats will be measured. Atrial Rhythm analysis is determined by examining leads V1, aVF, II and III in succession until the algorithm can determine the number of P waves per QRS complex. If the determination fails, no atrial rhythm parameter is calculated.

Axis Measurements

Instead of using the waveform amplitudes, the waveform areas are used to calculate P, QRS and T axis measurements for more accurate results. The sum of the ST onset, middle and end amplitudes is used in calculating the ST axis. The frontal plane axis measurements use the six limb leads to estimate the axis. The horizontal plane axis measurements are calculated from leads V1- V6.

Step 4: Interpretation

Based on waveforms and measurements the final diagnostic interpretation is performed. Each diagnostic category may be represented by only one statement in the final report. This statement is the most specific one encountered whose medical criteria were true based on the measurements, earlier decisions, and patient information (gender and age).

Overall Severity

Each interpretative statement selected for the ECG report has an associated severity. The severities associated with these statements are then combined to determine the overall severity for the 12-Lead ECG report.

12-Lead ECG Reports

Report Types

There are three types of 12-Lead ECG reports available:

- Diagnostic (captured) 12-Lead ECG reports from the 12-Lead ECG Application at the Patient Monitor
- Diagnostic (captured) 12-Lead ECG reports printed from the Information Center iX 12-Lead Review application
- Real-time 12-Lead ECG reports requested at the Patient Monitor (ECG Report A, ECG Report B)

Report Formats

The following 12-Lead ECG report formats are available:

Diagnostic ECG Report at Patient Monitor	Diagnostic ECG Report at Information Center iX	Real-Time ECG Reports A/B at Patient Monitor
3x4	3x4 (figure 26)	ECG3x4 (figure 22)
6x2	6x2	ECG6x2 (figure 23)
12x1	12x1 (figure 27)	ECG12x1
3x4 1R (figure 24)	3x4 1R	ECG4x2
3x4 3R	3x4 3R	ECG8x1 ^a
3x4 ST	3x4 ST MAP	ECG12x1 (2P) ^a
3x4 1R ST	3x4 1 R ST MAP	

Table 4: 12-Lead ECG Report Formats

a. Report orientation can be changed to portrait.

- For the Patient Monitors, the orientation of the 12-Lead ECG report is by default **Landscape**. For some formats, it can be changed to **Portrait** (see footnote above).
- For the Information Center iX, **Landscape** or **Portrait** orientation can be chosen for each 12-Lead ECG report.
- The 6 x 2 format and 12 x 1 formats show longer waveform segments in multiple leads that may be more suitable for reviewing arrhythmias.

Report Layouts

There are two configurable limb lead layouts for printed 12-Lead ECG reports: **International**: I, II, III, aVR, aVL, aVF, and **Cabrera**: aVL, I, -aVR, II, aVF, III.

Time Sequence

- The 12-Lead ECG Application at the Patient Monitors lets you define the time sequence for all leads, when displaying or printing two or more columns. Choices are **Sequential** or **Simultaneous**.
 - **Sequential**: All ECG signals start at 0 seconds in the first column, 2.5 seconds in the second column, 5.0 seconds in the third column, and 7.5 seconds in the fourth column. The ECG sequences are separated by single bars.

I	aVR	V1	V4
ECG part 1	ECG part 2	ECG part 3	ECG part 4
II	aVL	V2	V5
ECG part 1	ECG part 2	ECG part 3	ECG part 4
III	aVF	V3	V6
ECG part 1	ECG part 2	ECG part 3	ECG part 4
Rhythm Lead			
ECG part 1	ECG part 2	ECG part 3	ECG part 4
0 - 2.5 sec	2,5 - 5 sec	5 - 7.5 sec	7.5 - 10 sec

Figure 20: Sequential Time Format

- **Simultaneous**: The ECG starting point of each lead is the same time even though they may appear to start at different times on the ECG. The ECG sequences are separated by double bars.

I	aVR	V1	V4
ECG part 1	ECG part 1	ECG part 1	ECG part 1
II	aVL	V2	V5
ECG part 1	ECG part 1	ECG part 1	ECG part 1
III	aVF	V3	V6
ECG part 1	ECG part 1	ECG part 1	ECG part 1
Rhythm Lead			
ECG part 1	ECG part 2	ECG part 3	ECG part 4
0 - 2.5 sec	2,5 - 5 sec	5 - 7.5 sec	7.5 - 10 sec

Figure 21: Simultaneous Time Format

- At the Information Center iX the 3 x 4 format, the most commonly selected format, shows consecutive 2.5 second segments of the 12-lead, three leads at a time with a 10 second continuous rhythm strip displayed at the bottom of the report.
- Bedside monitor real-time 12-Lead ECG reports are formatted in the same way except that the 2.5 second segments are simultaneously obtained.

Lead Placement

- A 12-Lead ECG report obtained using EASI lead placement and setup at the IntelliVue Patient Monitor as EASI Lead placement will be labelled on the report as EASI. The 12-Lead ECG capture labelled as EASI will only contain time based basic measurements.
- If the user has placed the electrodes in modified electrode placement (Mason-Likar) and has set the Patient Monitor setting **Mod.LeadPlacement** to **On**, the 12-lead ECG report will be marked "Mason Likar".
- A 12-Lead ECG report obtained using Hexad 12-lead with 6-wire lead set will be labelled on the report as Hexad. The 12-Lead ECG captured from the Wave Review will have time-based measurements only.

IntelliVue Patient Monitor Diagnostic 12-Lead ECG Report

A typical IntelliVue Patient Monitor diagnostic 12-Lead ECG report is shown below (figure 22). This report is generated by selecting **Print Report** in the 12-Lead ECG Application and represents the 10 seconds of captured ECG. This report has not been sent to the PIIC iX for analysis.

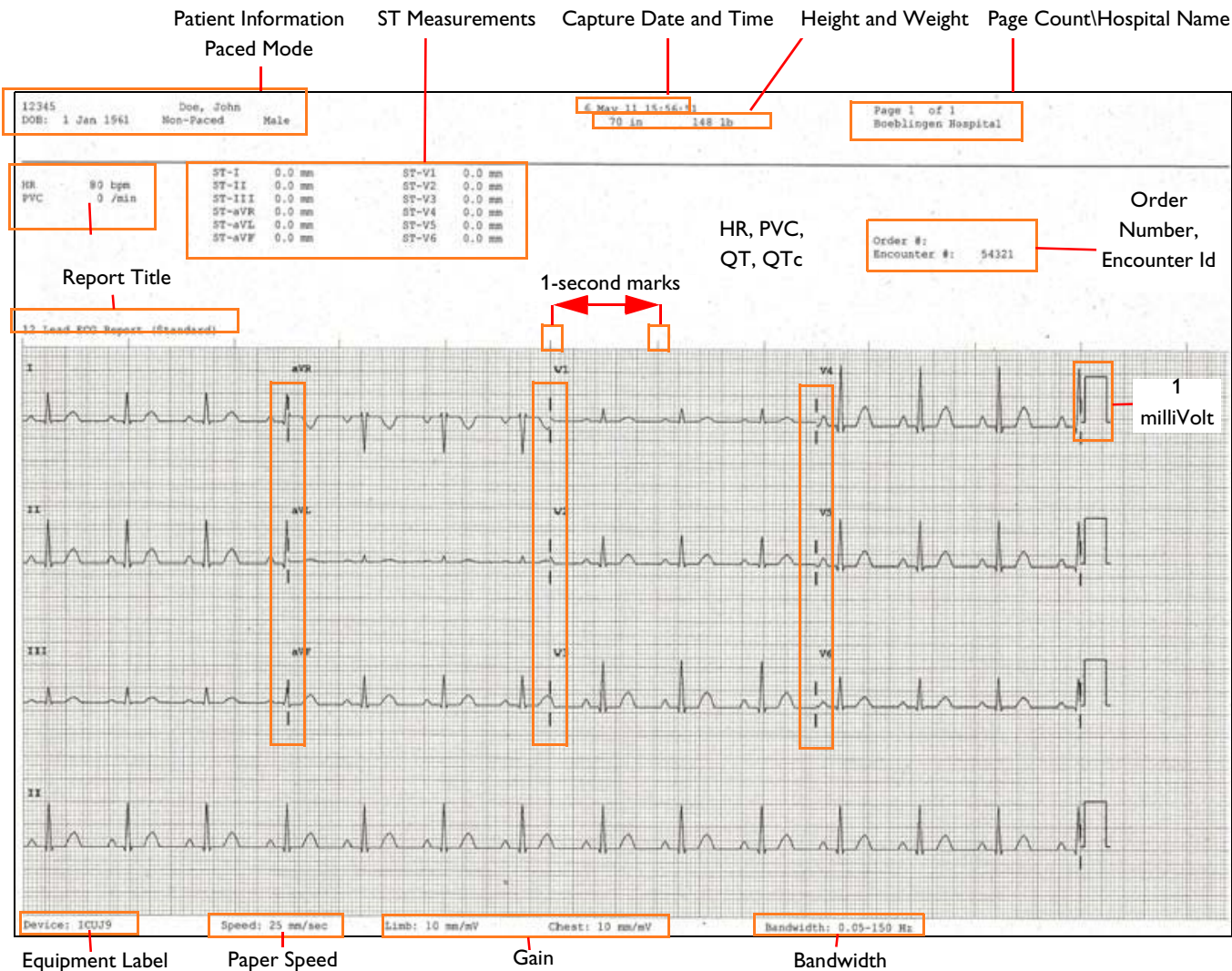
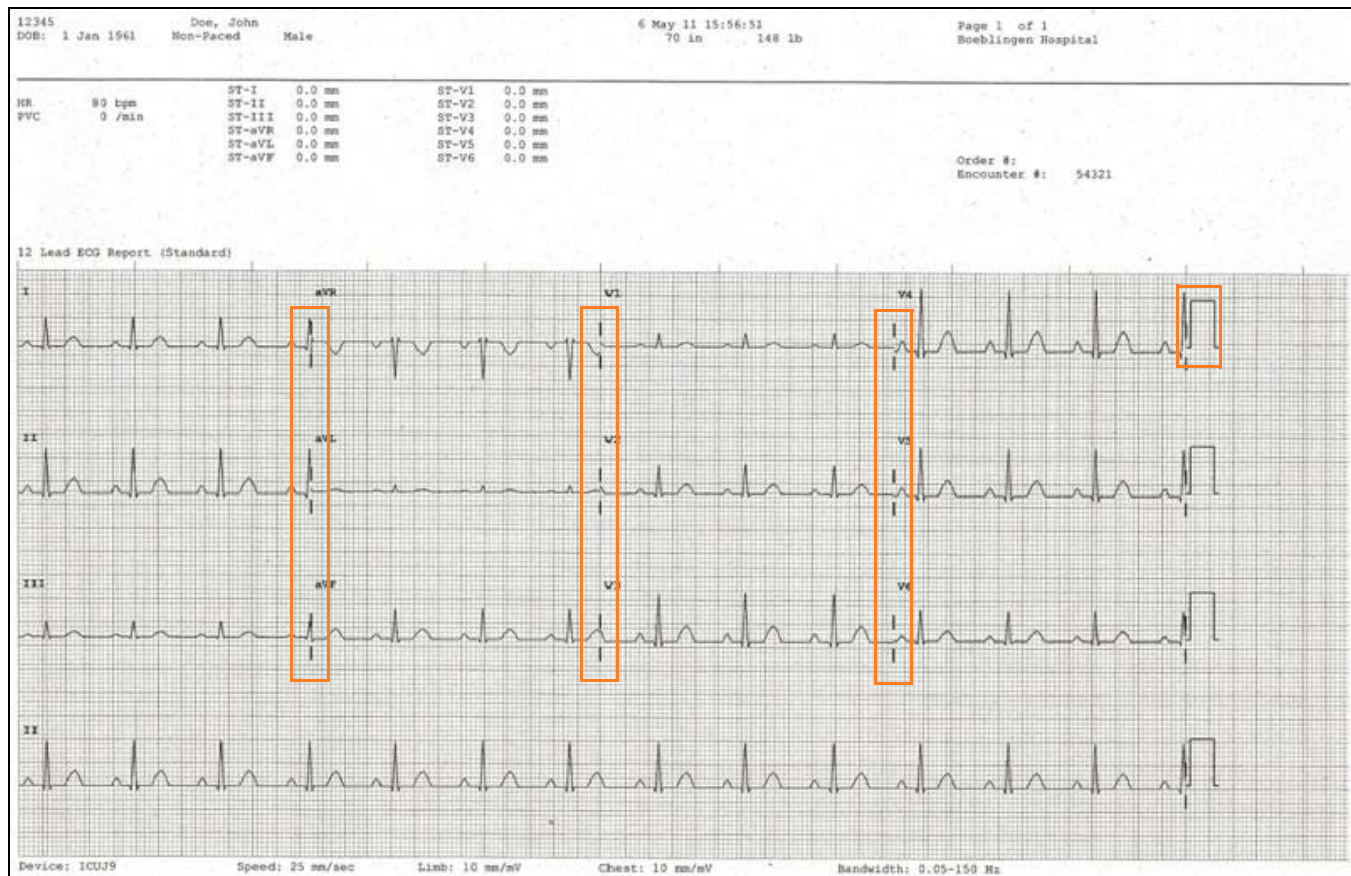


Figure 22: Patient Monitor 12-Lead ECG Report

Field	Notes
Patient Information, MRN, and Paced Mode	The Patient Name, date of birth, gender, and Medical Record Number (MRN) will appear on the report only if this information has been entered in the Patient Demographics Window. Paced mode can be changed in the Setup ECG menu, Patient Demographics window, or Profiles menu, and is stored with capture.
ST Measurements	ST measurements will appear on the 12-Lead ECG report if the ST analysis is turned on. These measurements are generated from the ST/AR ST analysis.
Date and Time	Capture Date and Time will always appear on the report.
Height and Weight	Height and weight will appear on the report only if this information has been entered in the Patient Demographics Window
Page Count	Page count will always appear on the report.
Hospital Name, Order Number, Encounter Id	Hospital name, Order number and Encounter Id will appear on the report only if this information has been entered in the Patient Demographics Window.
1 milliVolt Bar	The 1 milliVolt bar is the rectangular waveform shown at the end of the ECG trace. It shows for both limb and chest leads, how much the cardiograph deflected the trace in response to a 1 milliVolt pulse applied to the acquisition circuitry. The 1 milliVolt bar is a visual indicator of size. For half chest gain, the 1 milliVolt bar is stepped (see figure 25 on page 20).
Filter Bandwidth	The bandwidth is adjusted in Main Setup → Measurements → ECG → Setup ECG → 12 Lead → Filter . The bandwidth settings are applied to the 12-Lead ECG not as a real-time filter but in a manner which minimizes the distortion of the ST segment.
Paper Speed, Gain, and Chest Gain	Paper Speed, Gain and Chest Gain are adjusted in Main Setup → Measurements → ECG → Setup ECG → 12 Lead .
Bed Label	This is identical to the label displayed in the Monitor Info Line on the Patient Monitor. If the monitor is connected to an Information Center iX, the label is controlled by the Information Center iX. If the Patient Monitor is not connected to an Information Center iX, the label is the configured equipment label.
Report Title	The title of the captured report.
HR, PVC, QT, QTc	These are the HR, PVC, QT, QTc values which are displayed at the time of the capture.
1-second Marks	Short vertical lines at the top of the grid, marking one second.

Table 5: Fields of an IntelliVue Patient Monitor Diagnostic 12-Lead ECG Report

Examples of IntelliVue Patient Monitor Diagnostic 12-Lead ECG Reports

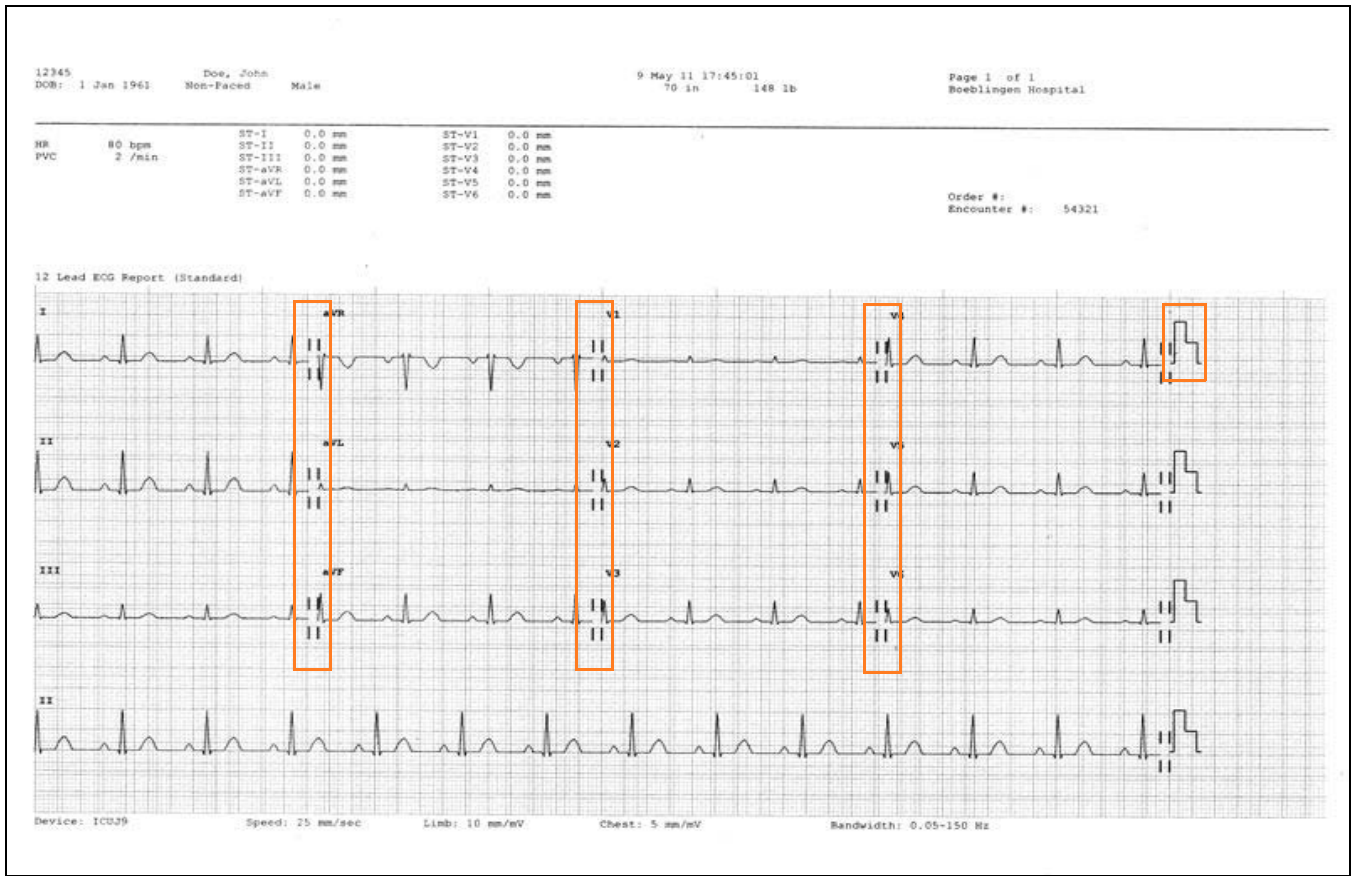


Single Bar Separation Symbol
with Time Setting **Sequential**



1 millivolt Bar
with Gain Setting **Full Chest Gain**

Figure 23: Diagnostic 12-Lead ECG Report at Patient Monitor '3x4 1R'; Time Sequential; Full Chest Gain



Double Bar Separation Symbol
with Time Setting **Simultaneous**



Stepped 1 millivolt Bar
with Gain Setting **Half Chest Gain**

Figure 24: Diagnostic 12-Lead ECG Report at Patient Monitor '3x4 1R'; Time Simultaneous In; Half Chest Gain

IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

A typical 12-Lead ECG report using conventional lead placement generated at the Patient Monitor and printed from either the Information Center iX or printed from the IntelliVue Patient Monitor 12-Lead ECG Application window after capture and interpretation is shown below (figure 25). It contains basic measurements, interpretative and severity statements, and status information.

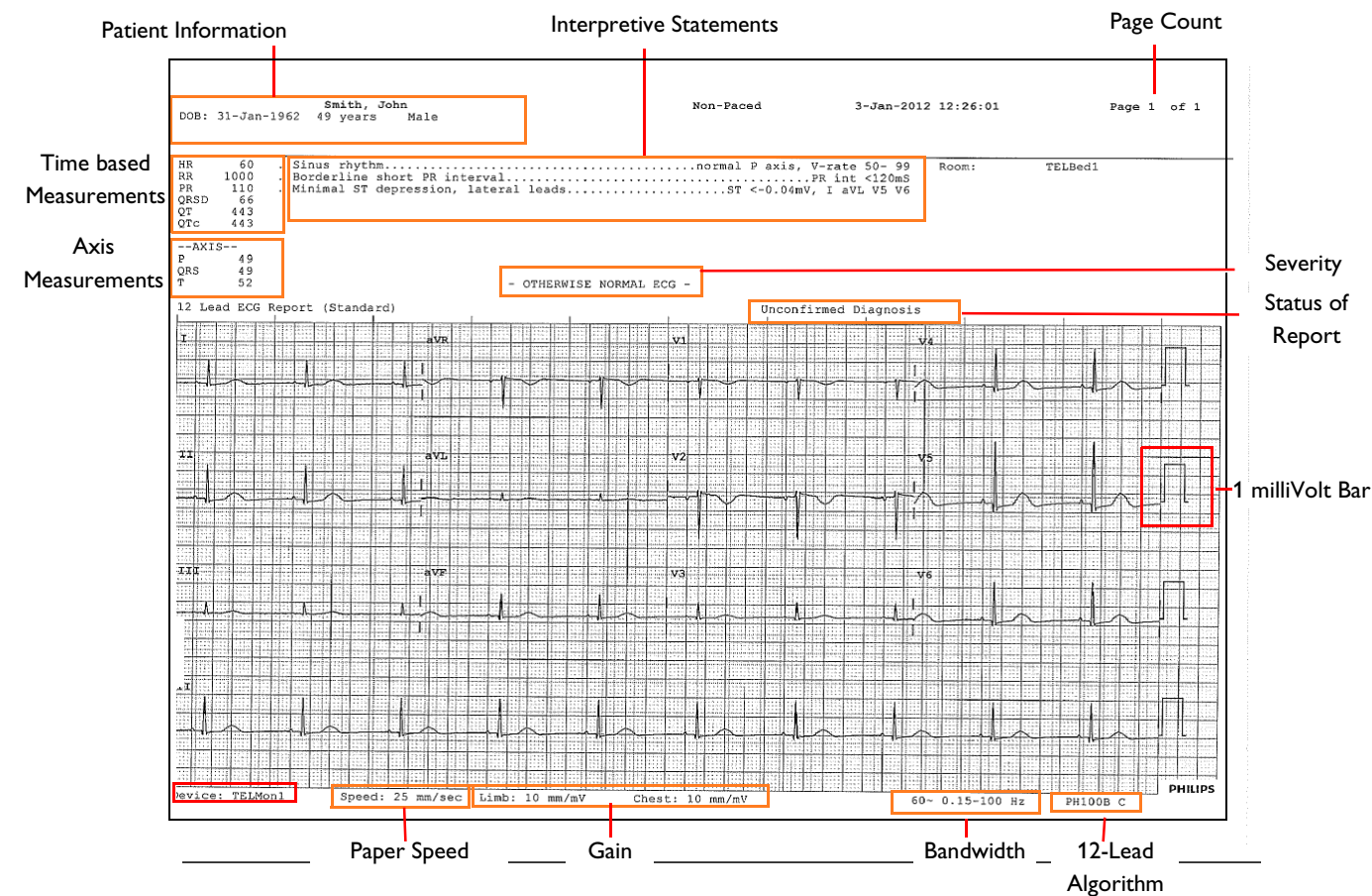


Figure 25: IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

Field	Notes
Patient Name, Medical Record Number, Date and Time	This section contains the date and time the report was captured and the patient identification information.
Interpretive and Reason Statements	This section contains the interpretive statements and the reason statements generated by the Philips 12-Lead ECG Algorithm. The interpretive statements (for example: SINUS RHYTHM) are listed at the left of the section in uppercase letters. Interpretive statements can also include a reason statement that summarizes the conditions that generated the interpretive statement (for example: normal P axis, V-rate 50-99). Interpretive statements can include quality statements that describe a signal quality problem that occurred during the recording, such as: ARTIFACT IN LEAD(S) I, III, aVL .

Table 6: Fields of an IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

Field	Notes
Page Count	Page count will always appear on the report.
Severity Statement	The severity statement represents the overall severity of the ECG.
Status of Report	The status of the report from the Information Center iX will be unconfirmed. This indicates that the ECG report has not been over read by a qualified physician. The 12-Lead ECG status can be changed once the ECG has been exported to a 12-Lead ECG Management system.
1 milliVolt Bar	The 1 milliVolt bar is the symbol shown on the first line of the ECG trace. It shows how much the cardiograph deflected the trace in response to a 1 milliVolt bar applied to the acquisition circuitry.
12-Lead Analysis Algorithm	Algorithm version used for analysis
Bandwidth Information	The 12-Lead ECG capture is transmitted to Information Center iX in diagnostic bandwidth (0.05 - 150 Hz). The 12-Lead ECG is analyzed using this bandwidth. It is displayed using the bandwidth settings from the 12-Lead ECG Review Application. The bandwidth settings are applied to the 12-Lead ECG not as a real-time filter but in a manner which minimizes the distortion of the ST segment.
Gain	Size of limb and chest leads.
Paper Speed	Paper Speed is changeable.
Axis Measurements	This section provides the P, QRS, and T axis measurements.
Basic Measurements	This section provides the heart rate, the standard interval and duration measurements, and limb lead axis measurements. These are representative values for the dominant beat pattern in the ECG.

Table 6: Fields of an IntelliVue Information Center iX Diagnostic 12-Lead ECG Report

Examples of IntelliVue Information Center iX Diagnostic 12-Lead ECG Reports

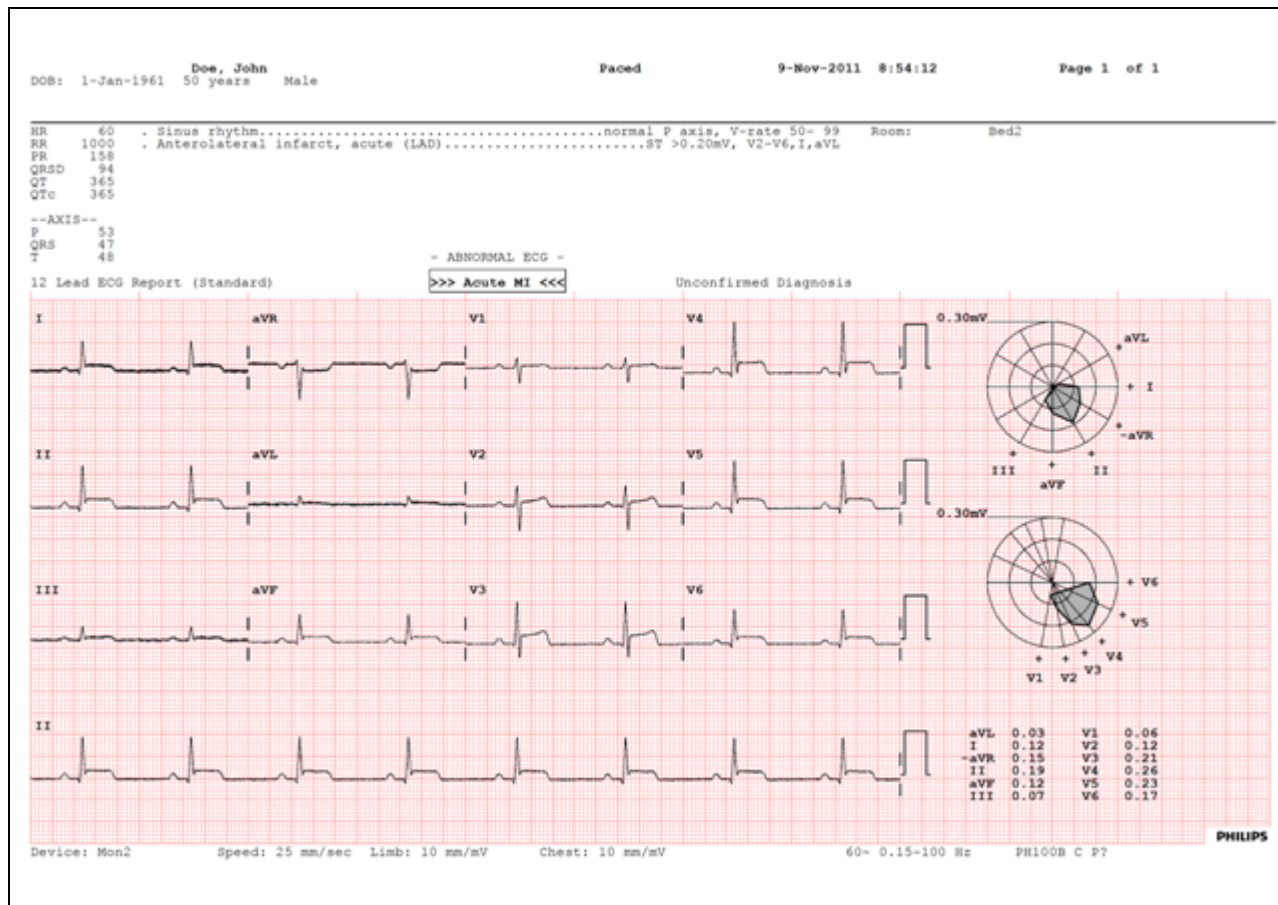


Figure 26: Diagnostic 12-Lead ECG Report at Information Center iX; '3x4 1R ST MAP'

IntelliVue Patient Monitor Real-Time 12-Lead ECG Report

A typical IntelliVue Patient Monitor real-time 12-Lead ECG report is shown below (figure 28).

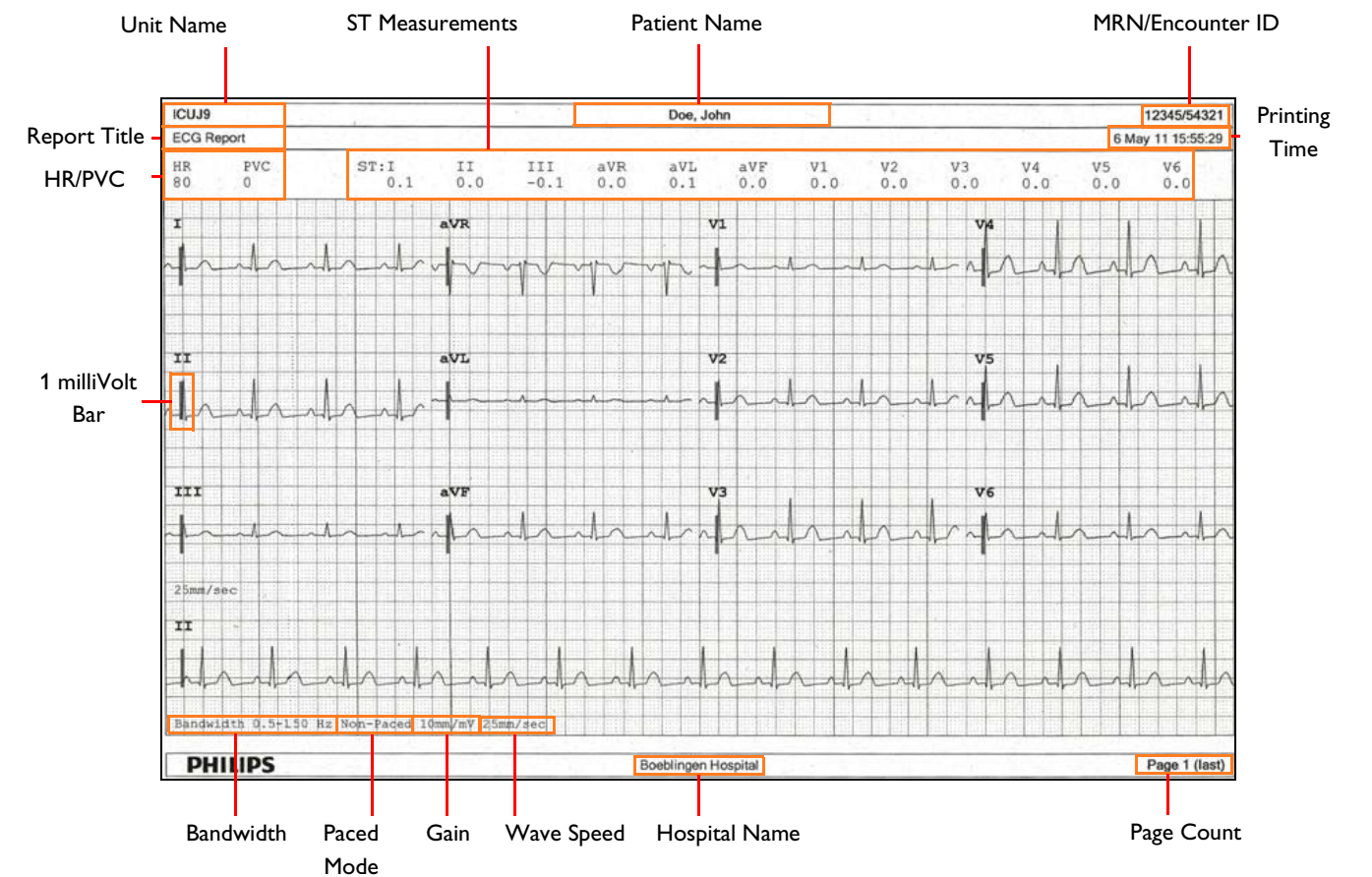


Figure 27: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report, 3 x 4 format

Field	Notes
Unit Name	The unit name if configured in the IntelliVue Patient Monitor.
ST Measurements	ST measurements will appear on the 12-Lead ECG report if the ST analysis is turned on. These measurements are generated from the ST/AR ST analysis.
Patient Name	The Patient Name will appear on the report only if this information has been entered in the Patient Demographics Window.
Medical Record Number and Encounter Id	The MRN and Encounter ID will appear on the report only if this information has been entered in the Patient Demographics Window.

Table 7: Fields of an IntelliVue Patient Monitor Real-Time 12-Lead ECG Report

Field	Notes
Bed Label	This is identical to the label displayed in the Monitor Info Line on the Patient Monitor. If the monitor is connected to an Information Center iX, the label is controlled by the Information Center iX. If the Patient Monitor is not connected to an Information Center iX, the label is the configured equipment label.
Printing Time	Printing date and time will always appear on the report.
Page Count	Page count will always appear on the report.
Hospital Name	The hospital or institution name if configured in the IntelliVue Patient Monitor.
Wave Speed	The actual wave speed of the real-time report.
Gain	The actual set gain of the real-time report.
Paced Mode	Paced mode can be changed in the Setup ECG menu, Patient Demographics window, or Profiles menu.
Filter Bandwidth	The bandwidth is set in the Main Setup → Measurements → ECG → Filter . If contour analysis is important use Diagnostic mode which minimizes the ST Segment distortion.
1 milliVolt Bar	The 1 milliVolt bar is shown under each lead name. It shows how much the cardiograph deflected the trace in response to a 1 mV calibration pulse applied to the acquisition circuitry. The 1 milliVolt bar is a visual indicator of size.
HR and PVC per minute	This is the HR and PVC count which is displayed at the time of the report.
Report Title	The title of the real-time report.

Table 7: Fields of an IntelliVue Patient Monitor Real-Time 12-Lead ECG Report

Examples of IntelliVue Patient Monitor Real-Time 12-Lead ECG Reports

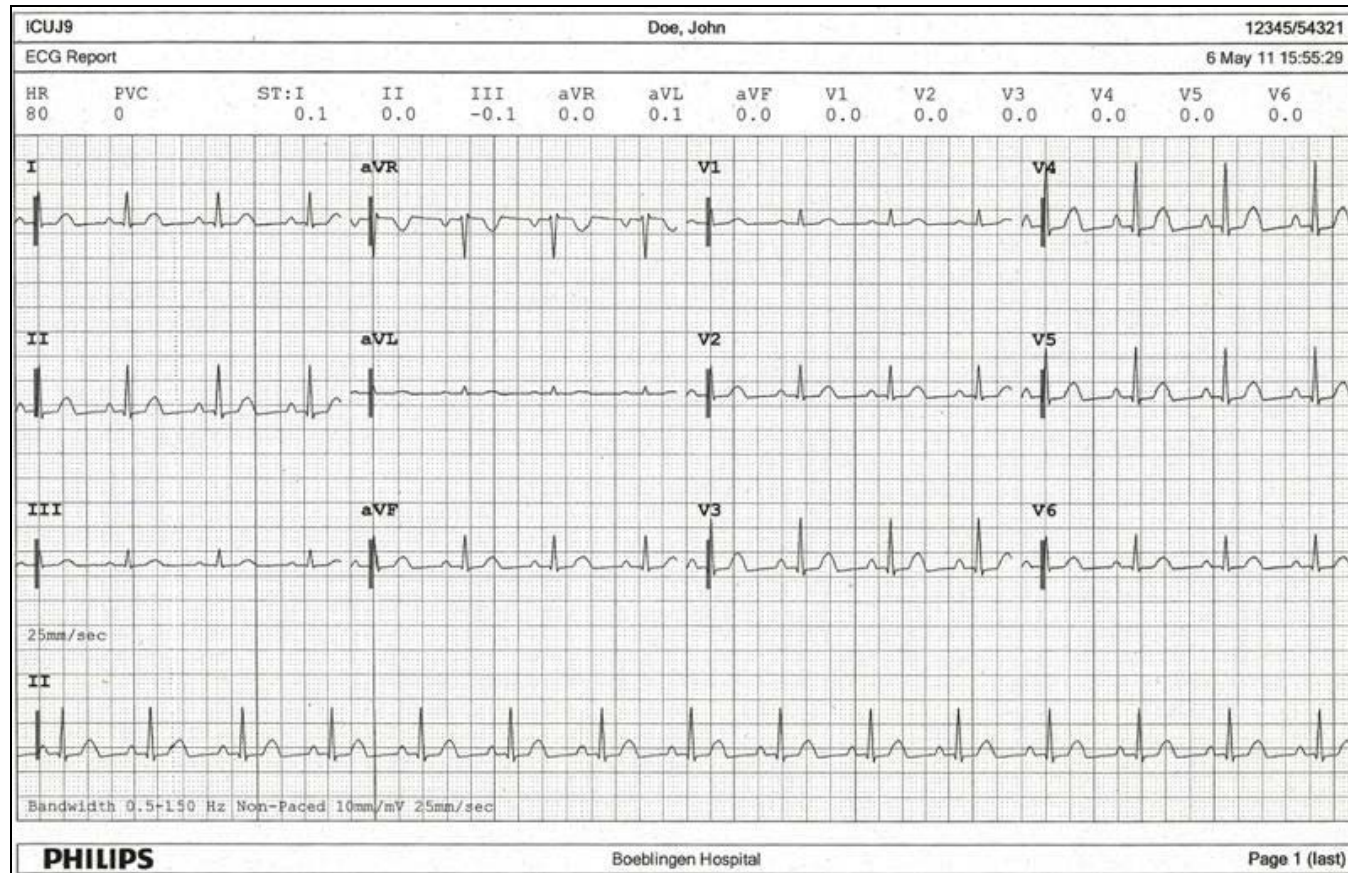


Figure 29: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report; 'ECG 3x4'

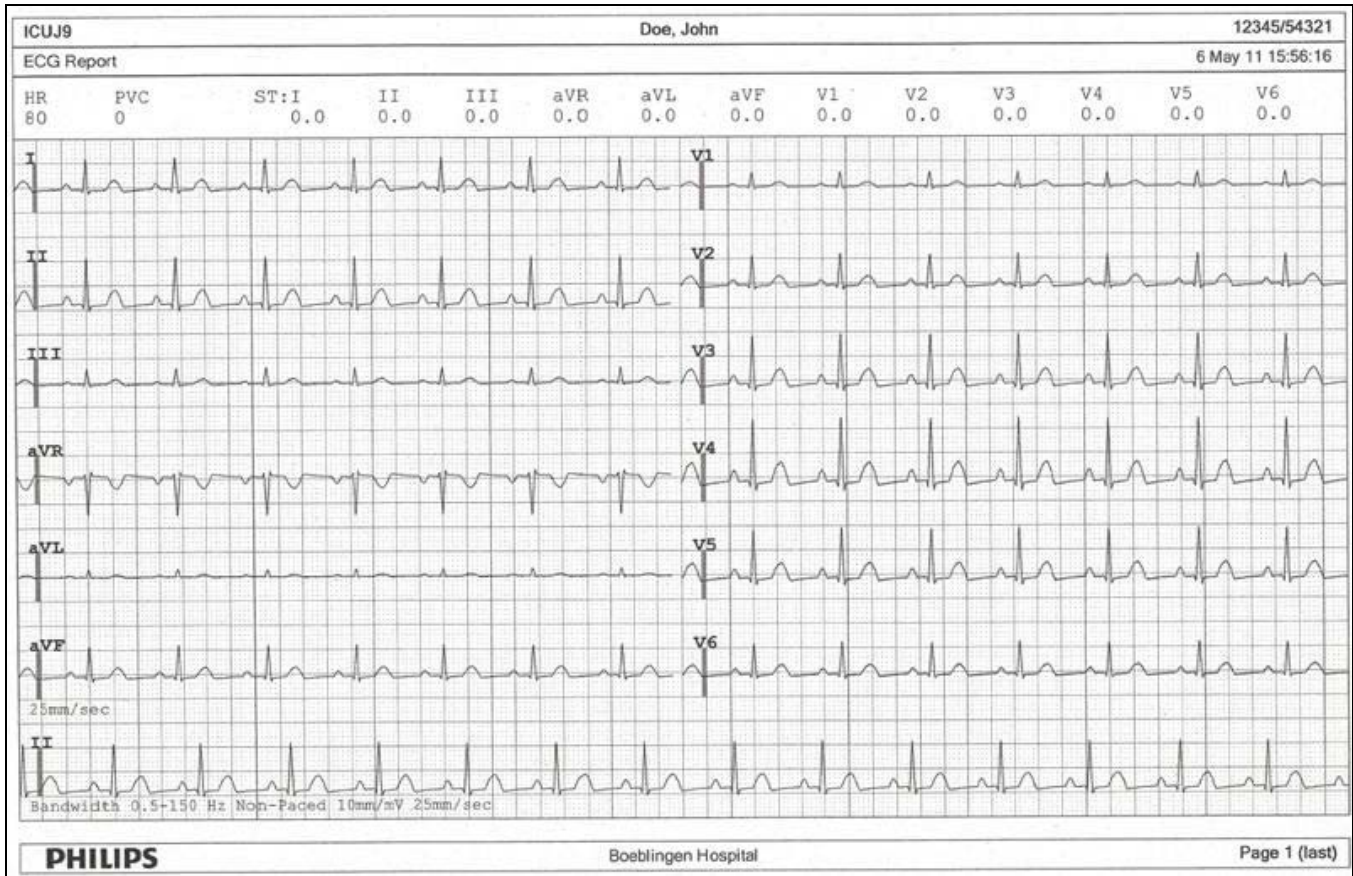


Figure 30: IntelliVue Patient Monitor Real-Time 12-Lead ECG Report; 'ECG 6x2'

Summary

The IntelliVue Patient Monitor provides a comprehensive ECG solution to meet both the diagnostic and monitoring needs of patients in critical care.

Monitoring (real-time) ECG

- Support for various ECG cable sets and lead placements
- Support for Hexad lead placement to generate derived 12-Lead ECG
- Support for EASI lead placement to generate derived 12-Lead ECG from a 5-electrode cable set
- Tailored monitor screens to view up to 12 leads of ECG as real-time waves
- ECG filters for both monitoring use
- Real-time ST analysis on all 12 ECG leads
- ST Map - a graphical display of ST segment data, providing a focused view that can help clinicians more easily recognize ST changes and location
- Real-time arrhythmia analysis and trending on one or multiple ECG leads using the Philips ST/AR algorithm
- Real-time ECG reports for documentation
- Real-time ECG recordings for documentation.

Diagnostic (captured) ECG

The dedicated 12-Lead Application on the IntelliVue Patient Monitor provides:

- Capture of 12-Lead ECGs in diagnostic quality
- ECG filters tailored for diagnostic use
- Entry of an ECG order number to facilitate order reconciliation
- Review of captured 12-Lead ECGs before they are stored and sent to the IntelliVue Information Center iX
- Storage of 12-Lead ECG data locally at the monitor
- Display results of 12-lead analysis received from the Information Center iX
- Review all 12-lead ECGs stored at the Information Center iX at the bedside
- Trigger export of captured 12-lead ECGs via the Information Center iX for long-term storage to an ECG management system, such as TraceMasterVue
- Print out of diagnostic 12-Lead ECG reports in various formats for documentation.

Captured 12-Lead ECGs can be sent to the IntelliVue Information Center iX, where:

- Up to 30 diagnostic 12-Lead ECGs can be stored per patient
- Captured 12-lead ECGs can be viewed in a dedicated 12-Lead Review application
- Captured 12-lead ECGs can be analyzed and interpreted using the Philips DXL ECG Algorithm
- Captured 12-lead ECGs can be exported for long-term storage to an ECG management system, such as Philips TraceMasterVue.



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Printed in The Netherlands.
4522 962 85101 Apr2012

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