PATIENTNET®
OPERATOR'S MANUAL

Software Version 1.04

Operator's Manual Part Number 10001001-00X, Draft

GE Medical Systems
Information Technologies

gemedicalsystems.com

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PatientNet® Operator's Manual

Technical/Service/Clinical Support

Our support professionals are ready to help you with operations and clinical application questions, parts replacement requests, supplies, technical and clinical training, or product service emergencies. We are available 24 hours a day, 7 days a week.

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- product name and serial number
- software version
- configuration information
- problem description
- your hospital's address and telephone number

Additional Resources

Additional literature is available as shown below. To obtain copies, contact your sales representative.

	part number
PatientNet™ Administrator's Guide, software v1.03	10001003-003
PatientNet™ Service Manual, software v1.01 and above	10001002-001
Central Station Quick Reference Card, v1.0X Series	10001036-004
IRVS Quick Reference Card, v1.0X Series	10001036-005
RVS Quick Reference Card, v1.0X Series	10001036-006

Contact the manufacturers of bedside monitors and ventilators used with PatientNet for literature on their equipment.

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INTRODUCTION

The PatientNet®System is intended to collect and analyze patient data from ECG ambulatory transceivers, leading manufacturers' bedside monitors, and ventilators anywhere in a healthcare facility and distribute the data to locations throughout the facility.

With OpenNet® technology, a hospital can connect bedside monitors from other vendors to the network. This allows standardization of display and distribution of patient information and may allow the use of existing equipment.

PatientNet software provides multi-lead arrhythmia analysis, user-configurable ST analysis, trend data, and a complete repository of monitored data. The PatientNet software version 1.04 supports the **W**ireless **M**edical **T**elemetry **S**ervices (WMTS) devices. The WMTS devices allow for the monitoring of over a thousand patients, as well as seamless roaming with the Access Points.

The following optional features are available:

- sending alarm information immediately to caregivers via the hospital's paging system or a stand-alone paging system
- linking to the hospital's existing network so that patient data can be viewed at any PatientNet Viewer
- accessing patient data using web browser-equipped computers on-site, and using the Internet off-site

Getting Started

The PatientNet System is intended for use in a hospital or clinical setting by trained and authorized personnel who are acting on the orders of a physician. The purpose of the system is real-time monitoring of adult patients over an extended period of time. Before you use PatientNet to observe patient vital signs, make sure of the following:

- you have read the *Statement of Clinical Use and Responsibility* in this manual.
- you have read the *Cautions and Warnings* at the front of this manual.
- you have received training on the equipment from authorized personnel.
- you are familiar with the medical terminology associated with monitoring critical care patients.
- you are familiar with the bedside monitoring devices.
- you or another person have programmed the transceiver as instructed in this manual, or the transceivers were previously programmed.
- you or another person have attached electrodes to the patient as instructed in the *Skin Preparation and Lead Placement* section of the manual.

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About This Manual

This manual presents the information and instructions you need to operate the PatientNet System. After you have been trained on the system, use it as a reference guide. This manual does not provide advice on interpreting patient data.

The following topics are covered in this manual:

- navigating the system
- placing ECG leads
- understanding alarm management
- viewing current patient status
- reviewing full disclosure and history data
- using transceivers

Technical Support and Literature Resources

Please refer to the Technical Support Information Sheet, located in the front of this manual, for details.

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Clinical Calculations

Heart Rate Accuracy

Ambulatory Patients

The heart rate accuracy of the Central Station for ambulatory patients meets the performance required for adult patients as specified in the Standard for Cardiac Monitors, Heart Rate Meters and Alarms ANSI/AAMI EC-13 1992 (3.2.7).

The heart rate is based on a tracked six-beat average. The following intervals are used for heart rate calculations:

- the interval preceding every detected beat during the learn
- the interval between two recognized morphologies after the learn

After each qualified beat, an instantaneous heart rate is derived from the preceding interval. The new heart rate is calculated as shown below.

New heart rate = (current rate - current rate/6) + (instantaneous rate/6)

Bedside Monitored Patients

The heart rate accuracy for bedside monitored patients is determined by the specifications of the bedside monitor.

NPB 7200 Series Ventilator Patients

There is no heart rate data for ventilator patients, but a pulse rate based on SpO_2 may be sent to the Central Station from the ventilator.

PVC Count

The PVC count is the number of PVCs (arrhythmia V-Calls) in the last 60 seconds.

If no PVCs occur for 12 seconds, the PVC count becomes zero even if there are PVCs within the last 60 seconds. However, if a PVC occurs in a subsequent 12 second period, then the total PVC count for the last 60 seconds is displayed.

If the PVC is part of a recognized ventricular arrhythmia (bigeminy, trigeminy, couplet, etc.), the called PVC count can lag behind the actual PVCs by up to 10 seconds.

When arrhythmia processing is off, the PVC count is removed.

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Clinical Use and Responsibility

CAUTION: United States Federal law restricts this device to sale by, or on the order of, a physician or properly licensed practitioner.

The PatientNet System provides the technology to monitor cardiac rhythms, vital signs, and equipment alarms for patients with various levels of acuity in multiple patient care settings.

The monitoring system does not replace physicians, caregivers or system operators. We recognize that machines are not capable of replacing human judgment, and emphasize the importance of the human element in the determination of any patient care interventions.

Implementation of clearly documented and communicated patient care guidelines and protocols accepted by the healthcare team is essential to the optimal use of the PatientNet System.

The following list is intended to provide guidance in determining potential high risk patients, but the actual definition for risk is a clinical judgment reserved for the caregivers.

- clinically unstable patients
- patients who require frequent intervention
- patients with pacemakers
- patients with a history of rapid or frequent rate and/or rhythm changes
- patients who experience dramatic changes in their QRS complexes
- patients receiving medications that could result in rapid or frequent rate and/or rhythm changes
- ventilator-dependent patients

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Warnings, Cautions, and Notes

Before operating the PatientNet System, read and follow all warnings and cautions provided in this section and throughout the manual.

The warnings and cautions in this section are general to the PatientNet System. Warnings and cautions that refer to specific functions of the system appear in appropriate sections of the manual.

Warnings

1. **PatientNet is designed to monitor patients; it is not an ECG diagnostic device. Any alarm or abnormal indication displayed by this system should be reviewed by a skilled clinical staff member to determine if the appropriate diagnostic procedure should be initiated.**
2. **Do not alter or add software to the system in any way. Any unauthorized change or addition of software and/or hardware to the system may affect patient safety or system efficacy, and will void your warranty.**
3. **When using a bedside device with the instrument transceiver (DT-7000/7001), the bedside device is the primary monitor and alarm source. Disabling alarms on the bedside device is not safe clinical practice.**

Electrical Warnings

1. **Use power conditioning and surge protection to protect the PatientNet System from damage and interruptions in operation in areas where power is subject to interruption, brownouts, frequency fluctuations, line noise, and spikes.**
2. **Accessory equipment connected to the analog or digital interfaces of the PatientNet System must be certified according to UL Electrical Safety Standards (UL 1950 for data processing equipment and UL 2601-1 or UL 544 for medical equipment). You are responsible for ensuring that any equipment which is connected to the PatientNet System complies with the applicable UL standards.**
3. **Do not place liquids on top of the equipment. Spilling liquids into the internal parts of the equipment may create an electrical hazard.**
4. **Verify that the system is connected to the proper AC power source before turning the system on, otherwise damage may occur to electronic components.**
5. **Always operate the PatientNet System with an Uninterruptible Power Supply to provide temporary backup power.**
6. **Our transceivers have been validated to comply with the requirements of CISPR 11 and IEC 601-1-2. To prevent electromagnetic interference, please ensure that any other equipment used within the vicinity of the patient meets the applicable requirements.**

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Equipment Safety Warnings

1. **Do not operate this system in the presence of flammable anesthetics. Such an environment presents the risk of explosion.**
2. **Do not obstruct air-holes on the unit. Improper ventilation and air flow may cause the unit to overheat, resulting in automatic shut down.**
3. **Do not alter the configurations of the Central Station, PatientNet Viewers (also known as the IRVS and RVS), associated antenna, and network components as installed by our service technicians. The PatientNet System is an integrated system and alteration to any component may compromise its performance.**
4. **Do not use transceivers that have been dropped, or damaged due to severe impact, until a biomedical engineer has inspected them. Cracks, openings, or other damage can compromise the electrical safety features of the transceivers.**
5. **Use only GE Medical Systems *Information Technologies* Power Supply Part Number 395005 with the DT-7000/DT-7001. The power supply must have a line isolated output that meets UL medical standards and cannot cause excessive patient current in the event of a bedside monitor isolation failure.**
6. **Grounding reliability can only be achieved when the Instrument Transceiver Power Supply, part number 395005, is connected to an equivalent receptacle that is marked "Hospital Grade".**

Cautions

1. **Do not tape or stick anything to the face of the touchscreen display. Doing so may cause the system to receive a false "touch signal."**
2. **Instruct ambulatory patients to remain within the range covered by the antenna system to avoid interruption of the transmission signal. The transceiver power is regulated by the FCC and, thus has a limited transmission range.**
3. **For optimal patient safety, operators and clinicians using the system should periodically review the system defaults set by the system administrator.**
4. **The Central Station and PatientNet Viewers are equipped with male and female AC sockets to accommodate various UL approved AC line cords. UL approval prohibits the simultaneous use of both AC sockets.**
5. **Do not open or modify any PatientNet component, unless otherwise stated, without approval by the manufacturer. Doing so will result in violation of your warranty.**

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Notes

- Consignment Central Stations are provided for the sole purpose of temporarily backing up the Central Station and PatientNet Viewers (IRVS and RVS). Consignment units do not have a software license; they use the license of the unit that they temporarily replace.
- The clock/time mechanism on the Central Station is accurate to +/- 1 minute per month. If greater accuracy is desired, then you will need to update the clock periodically.
- Daylight Savings Time must be manually adjusted. See the *PatientNet Administrator's Guide* for additional information.

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Definitions of International Symbols

The following table defines the international symbols that appear on the PatientNet Wireless Network™

Symbol	Name	Definition
	Attention	Consult accompanying documents
	Hazardous Voltage	Caution: Dangerous Voltages. Do not remove cover or back. Refer servicing to qualified service personnel.
	Off	Power is disconnected from main source
	On	Power is connected to main source
	Button	System on/off

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	Earth Ground	Functional. The device is electrically grounded.
	Defib Protection	This is a type BF equipment with Defibrillator protection
	UL Mark	Underwriters Laboratory classification mark
	UL Mark Listed	Underwriters Laboratory classification mark, indicating that the equipment is listed by UL.
	Fragile: Handle with Care	Storage / Transportation Packaging
	Keep Dry	Storage / Transportation Packaging

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+1060 hPa to +500 hPa -1252' to +18280'	**Temperature Limitation**	Storage / Transportation Packaging
	Humidity Limitation	Storage / Transportation Packaging
IPX7	**IPX7**	This device can be immersed in 1m of water for 30min.
IPX1	**IPX1**	This device is protected against vertically falling water drops.
FCCID:	**FCC Identification Number**	Unique Idenentification number that signifies the equipment is certified by the FCC.

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Software Help

Software Help is available to provide additional instructional support.

To use the Software Help:

1. Press **Help** on the Main screen to display the Help screen (fig. 1).

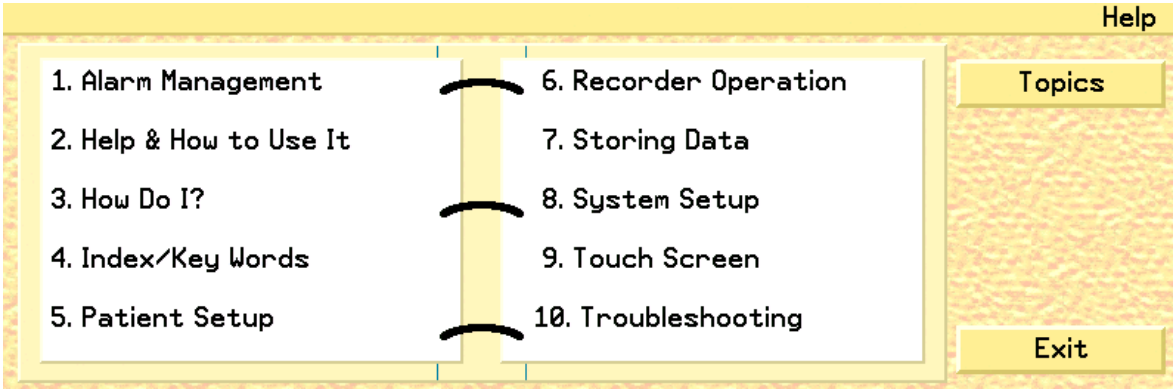

Fig. 1. Help Screen

2. Click on a help topic or click on **Index/Key Words** to display the Index screen (fig. 2).

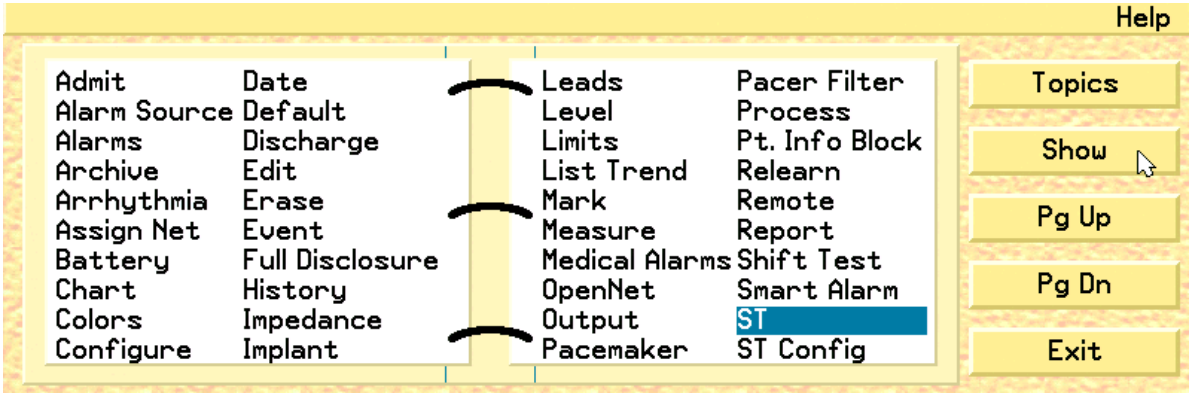

Fig. 2. Help Index Screen

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3. Select a topic and press the **Show** button to display the help information. Use the **Pg Up** and **Pg Dn** buttons to move through the topic choices.
4. Click the **Topics** button again to return to the Help Topics Screen. Select the **Help and How to Use It** topic (fig. 3) to view details on using the On-line Help function.

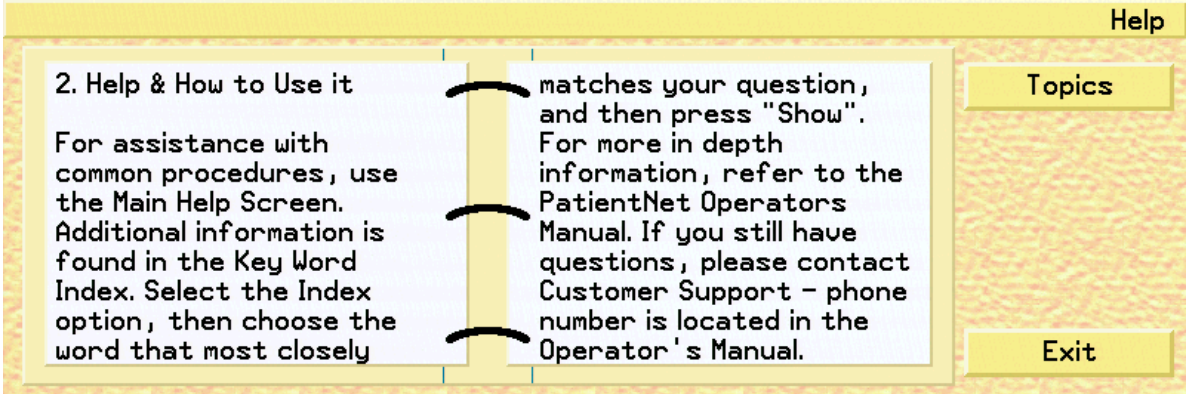

Fig. 3. Using the On-line Help Function

5. Click the **Exit** button to close the help system and return to the previous screen.

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Cleaning PatientNet System Components

CAUTION: Do not gas sterilize or AUTOCLAVE any part of the monitoring system or transceivers.

CAUTION: Do not allow liquid to come in contact with any display monitor of the Central Station, PatientNet Viewers (also known as IRVS and RVS), power cord, controls or switches. Doing so may damage and compromise the electrical safety of the equipment.

CAUTION: To avoid possible electric shock, the equipment must be turned off before cleaning. Do not turn off the equipment before consulting your facility's system administrator.

Keep equipment free from dust and dirt.

To clean, wipe the outside with a damp gauze or cloth and a mild cleaning solution. Use a cloth moistened with distilled water to rinse away the cleaning solution.

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THE PATIENTNET SYSTEM

About this Section

This section presents the following information or tasks:

- descriptions of the PatientNet System components (page 29)
- using the Main and Split screen elements (page 34)
- adjusting system volume (page 40)
- adjusting waveform and display colors (page 41)

The PatientNet® System is an open, real-time network that allows caregivers to access vital patient information from anywhere in the hospital enterprise. PatientNet is available for use with Hardwired technologies and **W**ireless **M**edical **T**elemetry **S**ervices (WMTS) technology. Transceivers at the patient level send patient data through the OpenNet Network to the Central Stations at Mission Control. From there, based on the options purchased, that data can be transmitted and viewed on any of the PatientNet Viewers

PatientNet System Components

Central Station

The Central Station is the main component of the PatientNet System. Each Central Station receives data via telemetry for up to eight patients (or 16 with a 16-channel system) and distributes it to remote viewing stations via a PatientNet Real-Time Network. Two to six Central Stations, as well as an optional IRVS, are grouped to form a pod. With this configuration, one system operator can monitor up to 48 patients (eight patients per Central Station) at a time. In addition, if a multi-mouse is installed, then the system operator can control all seven monitors with one mouse.

Multiple pods can also be connected to the same network. WMTS Central Stations are networked together on two logical networks; the OpenNet LAN for WMTS and Hardwired connectivity and the PatientNet Real-Time Network for viewer and server connectivity.

PatientNet Viewers

PatientNet Viewers are optional components that receive patient information from the Central Station via the PatientNet Real-Time Network and display it at convenient locations for the caregiver and administrative operations. They can access and display any patient information on the network.

There are two types of PatientNet Viewers:

- **I**nteractive-**P**atient**N**et **V**iewer™, which allows the modification of Patient Settings, and is also known as the **I**nteractive **R**emote **V**iewing **S**tation (IRVS).
- **P**atient**N**et **V**iewer™, which is view-only, and is also known as the **R**emote **V**iewing **S**tation (RVS).

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WMTS Remote Transceivers

Wireless **M**edical **T**elemetry **S**ervices (WMTS) Remote Transceivers provide the link between the patient and the Central Station through the new 608 - 614 MHz Medical Telemetry frequency band. They have the ability to send and receive data via the Access Point for data control command transfer and seamless roaming from Access Point to Access Point. The WMTS Remote Transceivers include the DT-4500 ambulatory transceiver, which is patient worn, and the DT-7000/DT-7001[1] instrument transceiver, which is attached to bedside monitors (OpenNet® Interface) or other medical instruments.

Access Point Transceiver

The DR-10000 Access Point transceiver is an Ethernet gateway that collects data from the WMTS Remote Transceivers, transmits data to the Central Stations on the OpenNet® Network, and sends or receives control data to/from the Remote Transceivers. The Access Point is typically mounted above the drop ceiling with cosmetic antennas mounted below the ceiling.

The PatientNet Access Point Transceiver is similar in concept to conventional wireless LAN “access points” (such as 802.11-compliant wireless LANs), but with the difference of having enterprise-wide synchronization and a higher level of data throughput efficiency. The DR-10000 is compliant with the Wireless Medical Telemetry Service (WMTS) rules for the 608 to 614 MHz band.

Optional Components

PatientNet Real-Time Network

The optional PatientNet Real-Time Network allows patient data on the network to be distributed to any remote viewing station in the facility. Thus, physicians and caregivers have access to real-time, continuous patient information anywhere there is a PatientNet Viewer or Interactive-PatientNet Viewer.

72 Hour Full Disclosure

When the 72 hour Full Disclosure option is enabled, Trend List and Full Disclosure data from the previous 72 hours will be available for review. The patient data will remain on the system for up to 72 hours before being erased.

Laser Printers

Laser printers can be connected to PatientNet systems; one laser printer can be shared among several Central Station units by means of print sharing devices. For practical purposes and ease of maintenance, do not connect more than six Central Stations to one laser printer.

Paging

PatientNet equipment interfaces to a variety of in-house hospital paging terminals and

1.The DT-7001 will be available in future releases. Please contact your sales representative for the device availability.

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stand-alone paging systems to alert caregivers of patient alarm conditions. Alphanumeric (nurse unit, room number, alarm condition, and extension) text messages are sent and displayed on compatible alphanumeric pagers.

Multi-mouse

Multi-mouse allows a single mouse to control multiple system screens. Up to six Central Stations and one Interactive-PatientNet Viewer in a pod configuration may be connected to a single mouse. Multi-mouse cables are connected from the mouse port of one unit to the next in a “daisy-chain” fashion. Multi-mouse movements are based on the pod configuration.

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System Configuration

Basic Configuration

A basic configuration (fig. 4) consists of the Central Station, which monitors, displays and prints data for up to eight patients. The Central Station may be connected to a laser printer and/or to the hospital's paging system. Central Stations can then be linked together to form a Pod (See figure 5 on page 33).

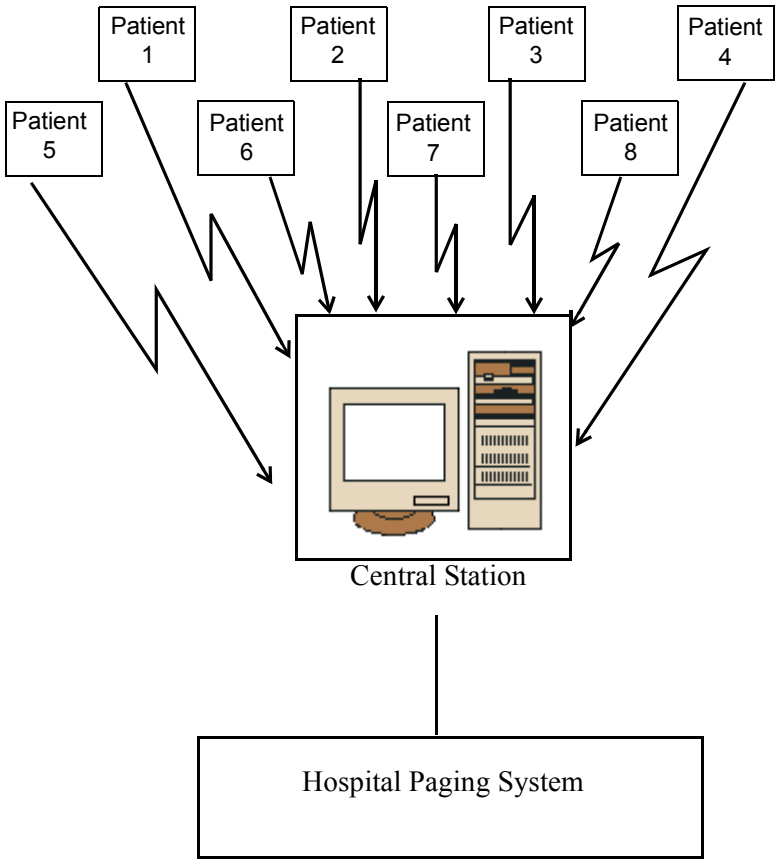

Fig. 4. Basic Configuration

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Pod Configuration

A pod configuration (fig. 5) consists of two to six connected Central Stations. An optional Interactive-PatientNet Viewer can also be added to a pod. With this configuration, one system operator can monitor up to 48 patients (eight patients per Central Station) at a time. Multiple pods can be connected to the same network.

When Central Stations are connected via the PatientNet Real-Time Network, patients can be transferred to different Central Stations on the network. The PatientNet Viewers allow you to select and view any patient on any Central Station that is connected to the network.

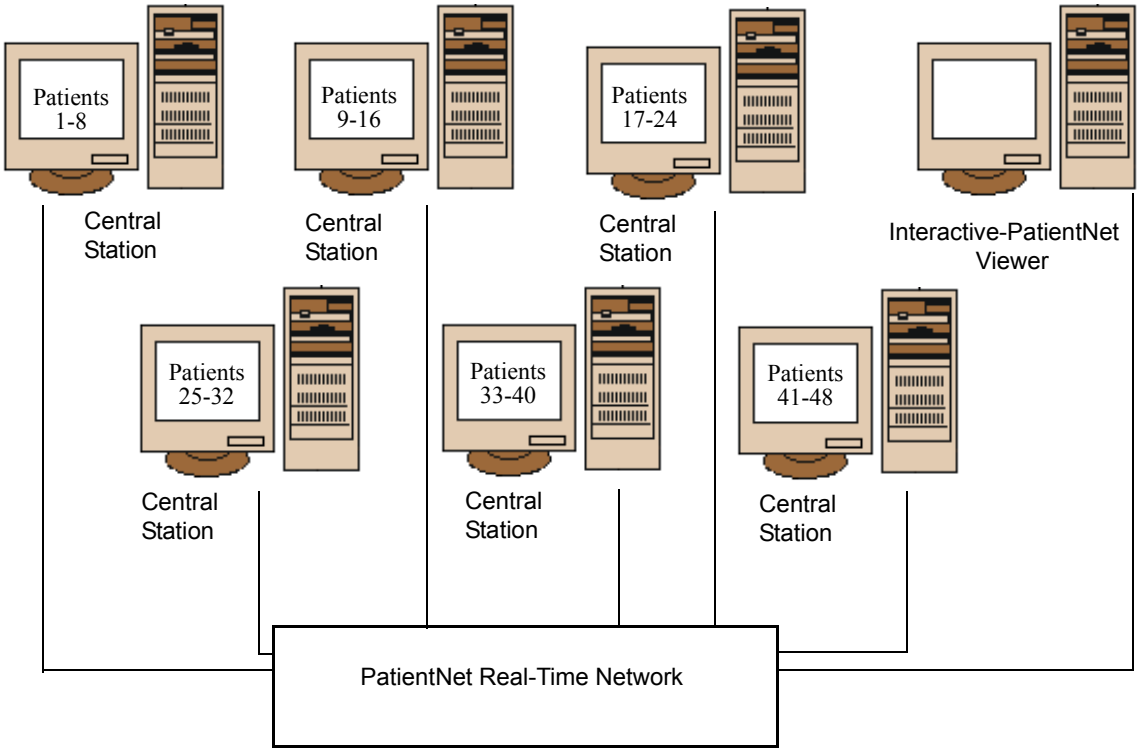

Fig. 5. Single Pod Configuration

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PatientNet Screen Elements

Main Screen

The Main screen of the Central Station, the screen normally used for monitoring, displays eight patient channels. Each channel is dedicated to one patient and displays that patient's real-time waveforms, monitoring data, patient demographics, and digital data.

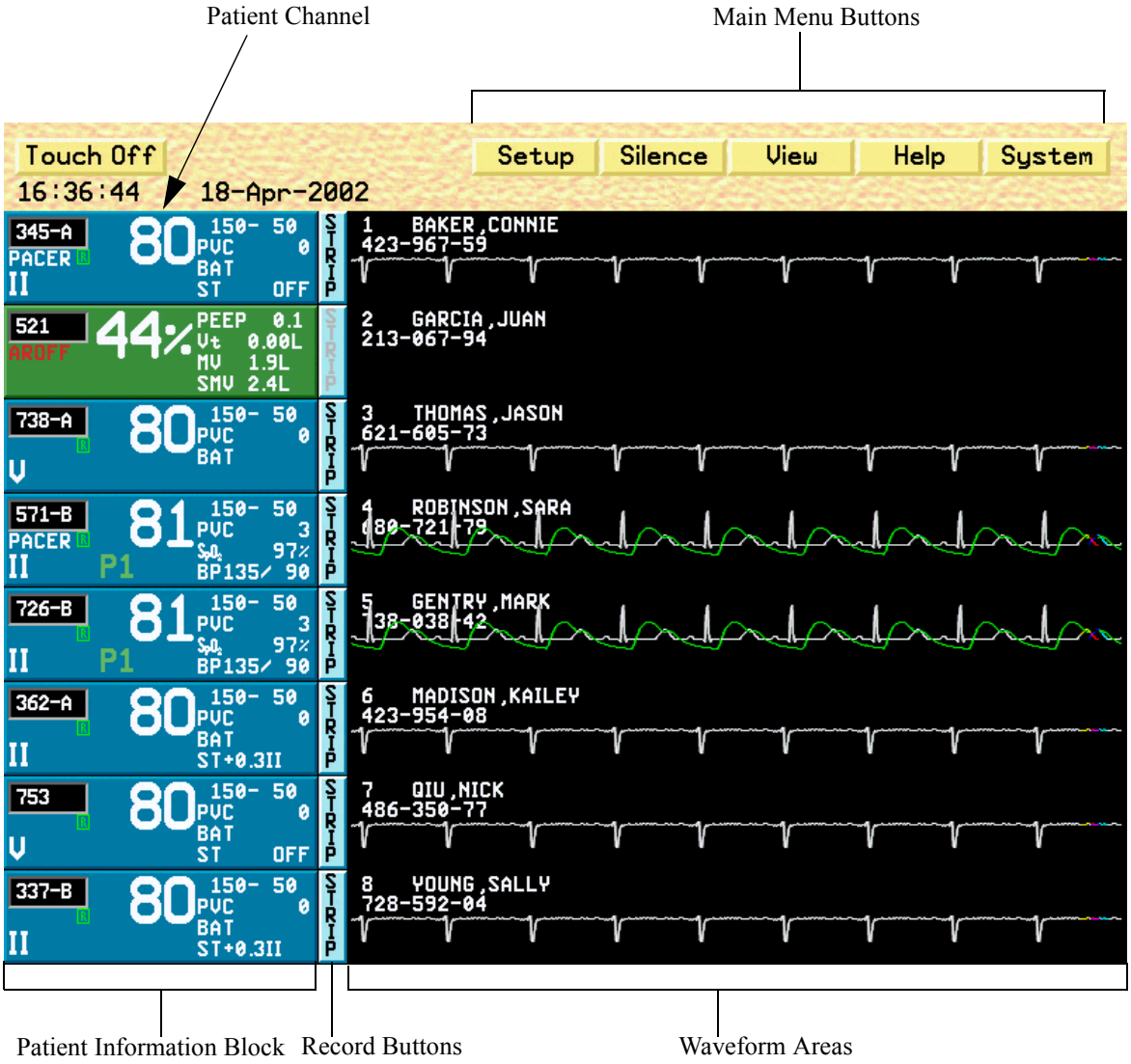

Fig. 6. Central Station Main screen

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Split Screen

The “split screen” format of the Main screen shows the eight channels but with a narrow window for waveforms; this makes room at the bottom of the screen for other applications. It is on the application screens that operations are performed.

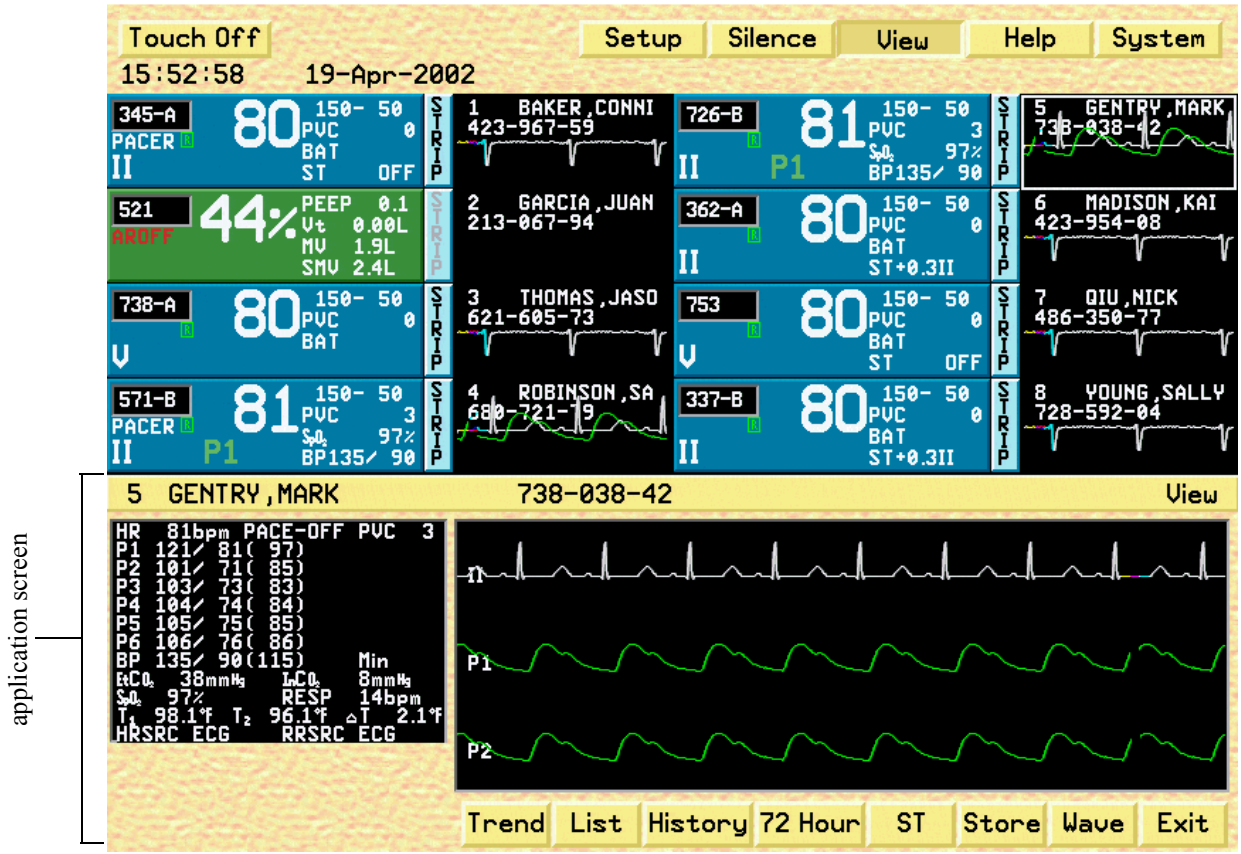

Fig. 7. Split screen

You can enter an application screen by either selecting a button from the main menu, or by selecting buttons within the currently open application.

Note: While viewing application screens, you may return to a previous screen by clicking the Exit button, or select a button from the Main Screen Menu Bar. Clicking a Main Menu Bar button may be more convenient at times than navigating through numerous application screen layers.

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Patient Channel Tile

Patient channels display the patient's name and other identifying information, current monitored parameters and data, alarms and waveforms. See "Admit, Discharge, and Patient Demographic Information" on page 73 for more information.

Patient channels are composed of the following:

- the patient information block, which comprises the main block and the configurable data block
- the record button
- the waveform area

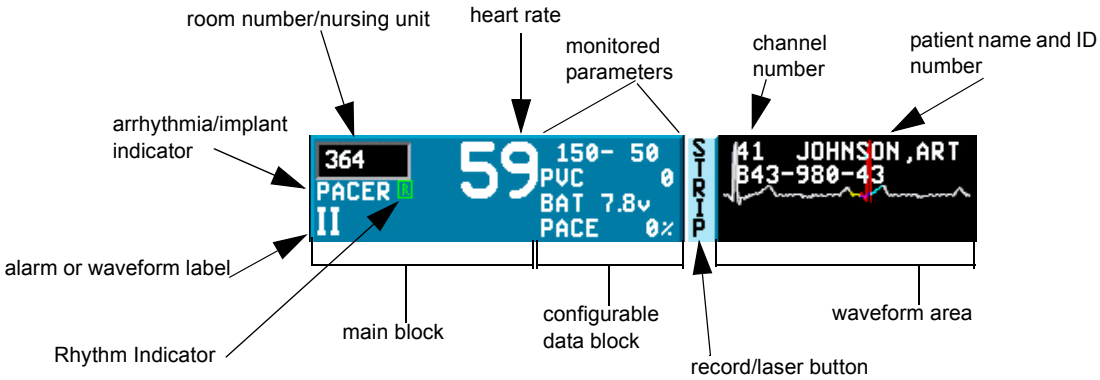

Fig. 8. Patient channel

Main Block Information

The main block shows the following patient information:

- room number/nursing unit (if configured)

Note: You can alternate between nursing unit, room number, and a scrolling marquee of both by clicking the room number/nursing unit box. This option is configurable; check with your system administrator if you are unable to change the room/nursing unit value that is displayed.

- heart rate (the pulse rate in the patient block is displayed in green and white for ventilator patients)
- arrhythmia or implant indicator: `BEDAR` if the bedside monitor performs arrhythmia processing, `AROFF` if arrhythmia is turned off, or implant type
- rhythm indicator, which appears as green, yellow, or red depending on arrhythmia beat quality.

Note: The rhythm indicator will flash in the patient tile when it turns red.

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- waveform label or `ALARM`, or one of the following:
  - `TRACE OFF`
  - `LEARNING`
  - Smart Alarm location
  - `ALARM OFF`
- silence indicator (crossed-out bell) in place of the Rhythm Indicator when an alarm is silenced

Note: Ventilator patient blocks are green, making them easily distinguishable from non-ventilator blocks. Patient Channels that are admitted via the Remote Admit feature are green until acknowledged by the Operator. Once you click on the green Remote Admit patient tile, the tile will turn blue.

Configurable Data Block

The configurable data block shows four parameters (and corresponding current data) that you select from the lists shown in "Selecting Monitored Parameters for the Configurable Data Block" on page 84.

Record Button

The record button prints waveforms and other patient information. If printouts take the form of strip recordings, the record button is labeled "Strip." If a laser printer is connected to your system, it may be labeled "Laser." Click the **Strip/Laser** button to generate a printout for that patient.

Note: The record button is not available for NPB 7200 series ventilator patients.

Waveform Area

The following appear in the waveform area:

- channel number
- patient name
- patient identification number
- approximately 7.5 seconds of the waveform(s) (full Main screen) for ambulatory and bedside monitored patients; no waveforms for NPB 7200 series ventilator patients

Printing Real-time Waveform Strips For All Patients

Most of the printing you do is on a patient-by-patient basis, and printing instructions appear in this manual where appropriate according to function.

You can, however, print out real-time waveforms for all admitted patients on the Central Station at one time. To do this:

1. Press **System** on the Main screen.
2. Press **Record All** button on the Passcode screen. A real-time waveform strip is printed to the laser printer or the strip recorder (depending on your system configuration) for all monitored patients.

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System Settings

You can optimize the visibility and sound level of PatientNet by making the color and sound adjustments described in this section.

Note: The settings you make here apply to all channels on the monitor.

Choose settings that are easiest to see and hear in your particular environment.

All of the settings in this section are made on the Passcode screen.

Display the Passcode screen by pressing **System** on the Main screen.

Fig. 9. Passcode screen

Adding Gridlines to Waveforms

Toggle the **Grid** button on the Passcode screen to turn gridlines on or off. Turning off the gridlines does not affect the background of printed waveforms.

Each square of the grid represents 0.5 mv vertically and 200 ms (0.2 sec.) horizontally. Every fifth vertical gridline is brighter than the others to provide a quick one-second reference.

Selecting the Mouse Pointer Color

Press **Mouse Color** to scroll through green, black, blue, white, or red. Notice that the mouse pointer changes color with each click. If you have a touch screen, the touch pointer does not change color; it is always white.

Record All Button

Pressing the **Record All** button causes a recording to be generated for each admitted channel.

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Cancel Laser Button

Pressing the **Cancel Laser** button cancels the currently printing laser output. Even though you press the Cancel Laser button, data may still be in the print queue. The printer will continue to print the data was in the queue prior to pressing the Cancel Laser button.

OpenNet Button

Note: The OpenNet Button is only available on the Central Station.

Pressing the **OpenNet** button displays the OpenNet Transceiver Status screen on monitors that are OpenNet LAN enabled.

Shift Test Button

Note: The Shift Test Button only appears on Page Popup enabled systems.

Pressing the **Shift Test** button sends a test page to all defined pagers.

To send a test page:

1. Press the **Shift Test** button.
2. A Shift Test popup will appear. Click **Yes** to send a test page or **No** to close the popup without sending a test page.

Page Button

Note: The Page button only appears on Page enabled systems.

Pressing the **Page** button allows you to send a manual page.

To send a manual page:

1. Press the **Page** button.
2. When the Page Dialog box appears, enter the Pager number and message.
3. Press the **Enter** button to send the page, or press the **Esc** key to return to the Passcode screen without generating a page.

Assign IRVS / RVS Button

Note: The Assign IRVS / RVS button only appears on IRVSs and RVSs.

Pressing this button invokes the Assign Interactive Remote Viewing Station or Remote Viewing Station screen.

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Sound Volume Adjustment

You can adjust the sound volume for Touch/Mouse clicks, Medical Alarms, and Technical Alarms.

To adjust the sound volume:

1. Press **Volume** on the Passcode screen to display the System Volume Setup screen.

Note: The Volume button is enabled and disabled by your System Administrator. If this button is disabled, check with your System Administrator for details.

2. Click on the appropriate slider bar and hold the mouse button down while you move the red slider up or down to select a volume, then release. A sample sound is generated when you release the mouse button.

Note: Make sure the mouse pointer is within the vertical bar when you release the mouse button. Otherwise, the volume will not change.

If you have a touch screen, touch the slider at the desired volume. A sample sound is generated.

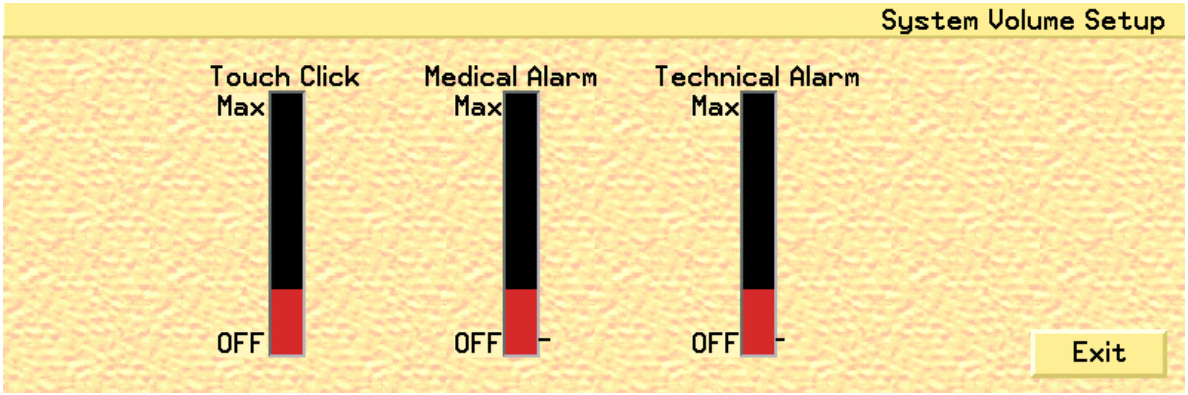

Fig. 10. System Volume Setup screen

Touch Click (mouse click): select a volume or turn the sound off.

Medical alarm: select a volume between **Min** and **Max**; you cannot turn the volume of medical alarms off.

Note: The minimum alarm limits are set by the System Administrator.

Technical alarm: select a volume between **Off** and **Max**, represented by tick marks on the right of the bar. (Maximum levels can be adjusted by the system administrator.)

3. Click the **Exit** button to return to the Passcode screen.

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Screen and Waveform Colors

You can adjust the screen and waveform colors to your preference on the System and Waveform Colors Setup screen.

Press **Colors** on the Passcode screen to bring up the System and Waveform Colors Setup screen shown in fig. 11.

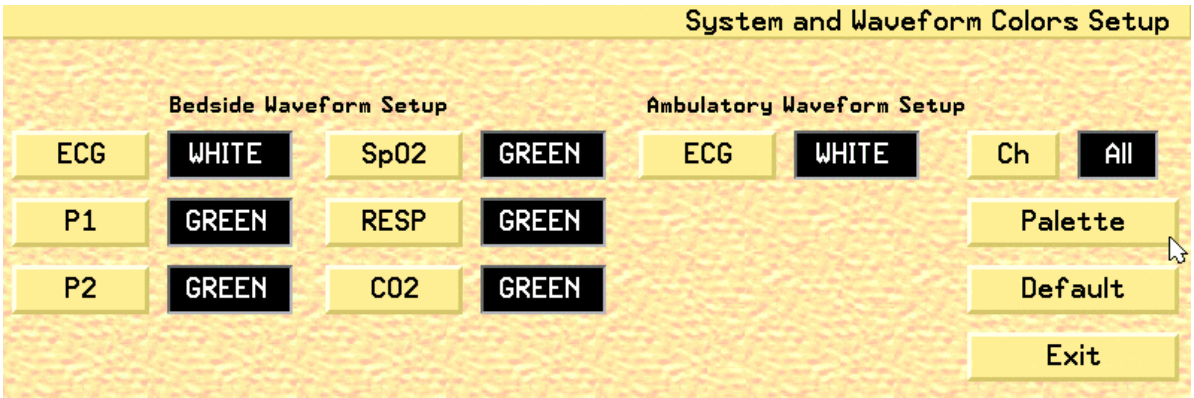

Fig. 11. System and Waveform Colors Setup screen

Screen Display Colors

Press **Palette** to scroll through the choices for display background colors.

Table 1. Default and Optional Palette Colors

Screen Area	Default	Optional
Patient Block Background		
• central alarm source	blue	blue
• bedside alarm source	dark blue	dark blue
• NPB 7200 series ventilator patient	green	green
Upper key background	yellow	yellow
Application screen background	yellow	yellow
Waveform background	black	white
Record button	light blue	light blue
ECG waveforms	white	black
Pressure waveforms	green	green
buttons	gold	gold

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Waveform Trace Color

Choose waveform colors for bedside monitored patients using the Bedside Waveform Setup buttons and for ambulatory patients using the **ECG** button under Ambulatory Waveform Setup.

Press these buttons to cycle through the color choices shown below.

Table 2. Waveform Trace colors

	Waveform	Color Choices	Default
Bedside Waveforms	ECG	white, red, green, yellow, blue	white
	P1	white, red, green, yellow, blue	green
	P2	white, red, green, yellow, blue	green
	P3	white, red, green, yellow, blue	green
	P4	white, red, green, yellow, blue	green
	P5	white, red, green, yellow, blue	green
	P6	white, red, green, yellow, blue	green
	SpO_2	white, red, green, yellow, blue	green
	RESP	white, red, green, yellow, blue	green
	CO_2	white, red, green, yellow, blue	green
Ambulatory Waveforms	ECG	white, red, green, yellow, blue	white

Channel Button (Central Station)

Press the **Ch** button to select which patient channel on the system will be changed. Pressing the **Ch** button will cycle through all available channels and then return to **All**.

The **Ch** default is **All**.

Channel Button [PatientNet Viewers (IRVS and RVS)]

Press the **Ch** button to cycle through the currently selected channels on the monitor, from the first viewed position (first top-left corner) to the last viewed position (last eight, bottom-right corner).

Default Colors

To choose system default colors as shown in table 1 on page 41 and table 2 (above) press the **Default** button.

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SKIN PREPARATION AND LEAD PLACEMENT

Patient Preparation for Monitoring

The single most important factor for accurate computerized arrhythmia monitoring is the quality of the ECG signal.

Electrode application is the critical step. Prepare the patient's skin to provide for good adherence of the electrode. This may seem time-consuming, but if done meticulously in the beginning to decrease skin impedance in the skin/electrode interface, much effort will be saved later. This step contributes greatly to the acquisition, analysis, and archival of accurate information in arrhythmia monitoring.

Each patient must have their individual monitoring needs met. Appropriate lead placement and selection is critical to this outcome.

Check the quality of the ECG signal. Four characteristics are essential:

- Artifact free
- Continuous
- Adequate signal strength
- Leads securely attached

If artifact is present, then the monitor will not be able to establish a good ECG reference in the learn mode and will have difficulty assessing the rhythm. If lead wires are broken, or the electrode contact is poor, then the signal will be interrupted. This may result in check signal, no signal, or false positive calls. Finally, if the signal does not have a minimum amplitude of reasonable size (0.5 mV), then it may not be recognized by the QRS detector and will result in false asystole calls. It is essential that the QRS amplitude exceed the P-wave amplitude. If the P-wave amplitude is too high, then the system may detect the P-wave instead of the QRS.

Computerized systems use mathematical descriptions of QRS complexes to assign arrhythmia categories. Motion artifact is mathematically similar to QRS complexes, but occurs less regularly in time and can therefore be misidentified as aberrant beats, V-FIB, or V-TACH.

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For stable electrode contact:

1. Clean and dry skin
2. Remove excess hair
3. Buff the skin briskly
4. Attach snap to electrode before applying
5. Place close to bone or over soft tissue
6. Secure wires and transceiver

Preventing or Minimizing Motion Artifact

Understanding and practicing the following seven concepts will greatly reduce the effect of motion artifact.

The electrical contact to the skin must be stable.

The electrical contact between the electrode and the skin involves three elements: (1) the electrode sensing element, a silver chloride button, (2) the electrode gel, and (3) the skin, which consists of the epidermis and the vascular layer immediately below the epidermis. The epidermis is not a good conductor of electricity. Motion of the epidermis results in changes in electrical contact and a variable signal.

The best and most stable contact occurs when the electrode gel is in contact with the vascular flow layer below the epidermis.

Changes in the electrode gel caused by wire or skin motion will, in turn, change the electrical signal that is seen by the electrode button. These changes are minimized, however, when the gel contacts the vascular layer of the skin rather than the epidermis. Buffing the skin increases contact with the vascular layer, therefore decreasing signal variation. Use of a 2 x 2 gauze pad, towel, commercially available prep tape, or other light abrasive to buff the site area will elevate the skin temperature, and bring the vascular blood flow closer to the surface.

Place electrodes close to bone or over soft tissue.

Muscle motion produces electrical activity. If electrodes are placed over muscular areas, such as the pectorals or oblique abdominals, they will detect this additional electrical signal. Although the system is designed to detect some muscle activity, and will recognize the QRS in the midst of muscle signal, some muscle activity and skin motion can cause false arrhythmia calls.

Electrodes are disposable and applied only once.

Attempts to replace a loose electrode guarantees excessive motion artifact and results in false alarms. If your electrodes contain *soft* gel, attach the snap onto the electrode and then apply it to the patient, pressing down on the adhesive rim only, so that the gel remains confined. If your electrodes contain *firm* gel, attach the snap onto the electrode, press down on the adhesive, and then press down on the center of the electrode, so that the gel is placed in direct contact with the skin.

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Note: Make sure that the expiration date on the electrodes has not passed. A dry electrode will not conduct.

The transceiver must be carried securely on the patient.

If the transceiver is allowed to dangle or jostle as the patient moves, then the weight of the device will tug on the electrodes, causing degradation of the signal. Even if the electrodes are in good contact, excessive tugging on the electrodes will change the physical structure of the gel, thereby generating motion artifact signals. Transceivers can be carried securely if you insert them into pouches or, place them into a patient's gown pocket. In addition, ensure that the lead wires are not twisted around one another as they each serve as an antenna.

Patient characteristics which require special attention in order to obtain a good contact.

The following types of patients may require special attention:

1. **Patients with dark or leathery skin**

   In these patients, resistance is high and generally, the ECG signal has a low amplitude. Skin motion will add large deviations to the baseline, and tugging effects are exaggerated. Buff the skin to elevate the temperature and bring the vascular flow to the surface.

2. **Patients with high perspiration levels**

   The main problems with these patients are lack of adhesion of the electrode and the dilution of the gel. However, when the skin is moist and pores are open, there is a greater ability for the gel to penetrate the epidermis. Again, buff the skin to remove excess moisture and elevate the temperature.

3. **Patients who have lost large amounts of fat or muscle mass**

   Even if a good contact is made, skin movement is excessive. Minimum artifact may be achieved by careful placement close to bone. Electrodes need to be positioned away from areas with large amounts of fat or muscle mass, as the vascular layer is farther from the epidermis. Therefore, the signal quality will be reduced. To stabilize, the electrodes may need to be moved higher or more laterally on the patient.

4. **Patients who have midline surgical dressings and wounds**

   The brown chest lead can be moved to the V3-V6 area. (page 48)

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Electrode Placement on Ambulatory Patients

WARNING: ECG lead wires must be dressed and secured to the patient to prevent the possibility of them encircling the patient's neck and causing strangulation.

CAUTION: The type of electrode used with this device may affect the system overload recovery time, especially recovery time after the application of defibrillator pulses, since some electrodes may be subject to large offset potentials due to polarization.

Unit protocol usually dictates the best lead to be displayed on the Main screen. If the R wave on the lead is small, it is advisable to consult the 12-lead ECG in the patient's chart to choose a lead with a more prominent R wave.

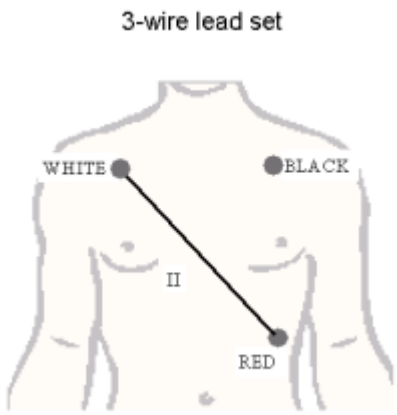

Fig. 12. 3-Wire Lead Set Placement

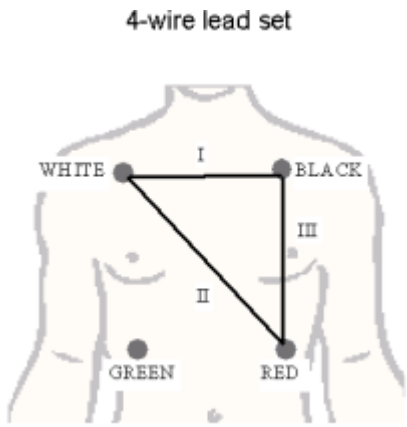

Fig. 13. 4-Wire Lead Set Placement

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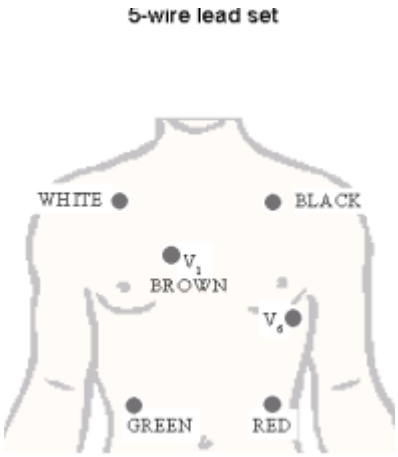

Fig. 14. 5-Wire Lead Set Placement

The following table describes the electrode positions and corresponding colors.

Table 3. Electrode Positions and Colors

Electrode	Color	Position Description
RA	White	Second intercostal space at right mid clavicular line
LA	Black	Second intercostal space at left mid clavicular line
LL	Red	Lowest palpable rib at left mid clavicular line
RL	Green	Lowest palpable rib at right mid clavicular line
V1	Brown	Fourth intercostal space (right sternal border)

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Alternative Placement of Electrodes

Surgical Patients

Place the Brown electrode in the area of the V_5 chest lead.

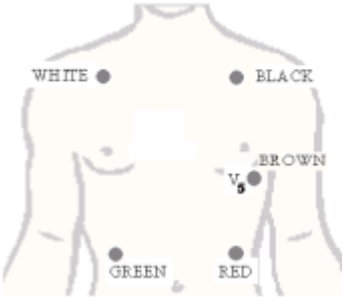

Fig. 15. Surgical Patients Lead Placement

Patients Using Transcutaneous Electrical Nerve Stimulators (TENS)

TENS signals may saturate the signal and can interfere with, or result in gross distortion, of the ECG waveform. This may result in false asystole or low heart rate alarms. It also affects the displayed ECG waveform. The following interventions are recommended:

- Reposition the leads attempting to adjust their position relative to the TENS unit. Follow the steps detailed for repositioning the leads for patients with pacemakers (see “Patients with a Pacemaker” below).
- Refer to the operator’s manual that is provide by the manufacturer of the TENS unit.
- If TENS signals continue to interfere with ECG monitoring, and if ECG monitoring is critical to patient care, you may need to make the clinical decision to discontinue TENS pain management.

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Patients with a Pacemaker

Note: Do not place an electrode near the implant. Move the relevant electrode at least four inches, either lower on the chest or near the scapula. The chest lead may also have to be moved.

Note: Initiate the learning process when the patient is in their dominant rhythm.

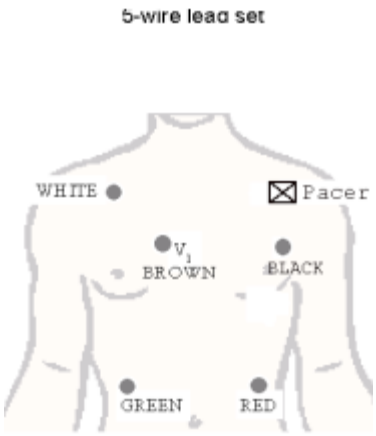

Fig. 16. Pacemaker Patients Lead Placement

The transceiver detects pacemaker pulses on Leads I and II. The more parallel these vectors are to the pacing vectors, the more likely the pacer pulses will be detected. The impedance pulse vector is typically positioned between the pacemaker implant and the pacing lead in the bottom of the heart. In adults, the pacemaker is usually implanted in the left or right pectoral area. To better reject the impedance pulses, the following lead placement guidelines may help.

Left Arm Implant: Reposition the LA Electrode

The impedance vector runs from the left pectoral region to the bottom of the heart. Since Lead II should be perpendicular to this vector, Lead I is most likely the difficulty. Moving the left arm electrode accomplishes two things:

1. The electrode is moved farther from the pacemaker; typically three or four inches below the standard lead position.
2. The Lead II vector is more perpendicular to the impedance vector, reducing the likelihood of false pacemaker detect triggers.

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Right Arm Implant: Reposition the RA Electrode

The impedance vector runs from the right pectoral region to the bottom of the heart. Begin to work with Lead II. This will accomplish two things:

1. The electrode is repositioned farther from the pacemaker; typically three to four inches to the right (towards the center of the chest).
2. Lead II is made less parallel to the impedance vector, reducing the likelihood of false pacer detect triggers.

If this does not produce the desired results, try moving the left leg (LL) electrode upward to make the Lead II even more perpendicular to the impedance vector.

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ARRHYTHMIA ANALYSIS

PatientNet performs arrhythmia analysis on ambulatory and bedside monitored patients. Arrhythmia processing is not performed when the device type is a NPB 7200 series ventilator.

WARNING: This device does not detect all arrhythmias. This device has been designed and validated to detect the following arrhythmias only:

ASYSTOLE	**SV-TACH**	**V-RHYTHM**
COUPLET	**BIGEMINY**	**V-TACH**
V-FIB	**PVC and high PVC**	**TRIGEMINY**
V-RUN		

Overview

Arrhythmia Analysis

Arrhythmias are detected for both ambulatory and bedside monitored patients by using up to two leads of ECG, depending on the number of leads available.

The leads are chosen for analysis in the following priority order: V, II, III, I, and all other lead types (e.g., aVR, aVL, etc.).

Note: You can select (if available) the Primary and Secondary leads that will be used for arrhythmia analysis. For best results, select lead II for the Primary lead, and lead V or I for the Secondary lead.

QRS complexes as well as high and low heart rates are detected over the range as specified in the Standard for Cardiac Monitors, Heart Rate Meters and Alarms ANSI/AAMI EC-13 1992 (3.2.6).

Note: The DT-4500 Ambulatory Transceiver supports 3, 4, and 5-wire at this time.

Note: Please see “Reporting” on page 222 to report questions or problems related to Arrhythmia analysis.

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V-TACH, V-RUN, and V-RHYTHM Configurations

V-TACH

The V-TACH arrhythmia alarm can now be configured. The number of consecutive PVCs can be set equal to, and between, 3 and 8. The Heart Rate can be set equal to, and between, 100 and 120 BPM. A V-TACH alarm is triggered when the consecutive PVC count is reached AND the heart rate is greater than or equal to the set Heart Rate Value.

V-RUN

V-RUN is triggered when the number of consecutive PVCs is greater than 2 and less than the V-TACH configured PVC value (i.e. when the V-TACH is configured at 3 PVCs, the V-RUN alarm is never triggered).

V-RHYTHM

V-RHYTHM is triggered when the number of consecutive PVCs is greater than or equal to the V-TACH configured PVC value, but the Heart Rate is less than the V-TACH configured heart rate value.

V-TACH Setting	Patient Rate and Rhythm	Alarm Triggered
3 PVCs and 100 BPM	3 PVCs and 100 BPM	V-TACH
3 PVCs and 110 BPM	3 PVCs and 100 BPM	V-RHYTHM
3 PVCs and 110 BPM	3 PVCs and 110 BPM	V-TACH
5 PVCs and 100 BPM	4 PVCs and 90 BPM	V-RUN
5 PVCs and 100 BPM	5 PVCs and 90 BPM	V-RHYTHM
5 PVCs and 100 BPM	5 PVCs and 100 BPM	V-TACH
8 PVCs and 120 BPM	6 PVCs and 100 BPM	V-RUN
8 PVCs and 120 BPM	8 PVCs and 100 BPM	V-RHYTHM
8 PVCs and 120 BPM	8 PVCs and 120 BPM	V-TACH

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Bedside Arrhythmia Source

Some bedside monitors can perform arrhythmia processing and generate their own arrhythmia alarm calls. You can elect to have the system use such bedside monitors for arrhythmia processing and the Central Station's arrhythmia processing will be turned off for that particular channel. To do so, set the patient's alarm source to bedside and set arrhythmia/ST to ON on the Alarm Source popup described on page 116.

Arrhythmia alarms are called regardless of whether arrhythmia is ON or OFF on the Central Station when arrhythmia is processed by the bedside monitor.

The Central Station displays and prints ST digital data, % paced digital data, and PVC count for bedside arrhythmia source patients (if these parameters are supported by the bedside monitor).

BEDAR appears in the patient block of bedside source patients, and BEDARR appears on printouts, history and full disclosure.

Central Arrhythmia Source

If the patient's alarm source is set to Central and Arrhythmia/ST is ON (see page 116), the Central Station performs all arrhythmia processing.

Arrhythmia Turned Off

You can set Arrhythmia/ST to OFF in the Alarm source popup. AROFF appears in the patient block, and ARROFF appears on printouts, history and full disclosure.

When Arrhythmia/ST is set to OFF:

- the system does not perform arrhythmia processing.
- zero rate alarm is called in place of arrhythmia alarms.
- annotations are not present in Full Disclosure.

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Computerized Arrhythmia Monitoring

Computerized arrhythmia monitoring was never intended to replace the human interface as the mathematical brain of the computer does not think like ours. It does one thing better than us however, and that is to provide continuous surveillance of all monitored patients simultaneously without fatigue or distractions. The networked monitoring system has a series of alarm messages and tones to alert clinicians when a change in the patient's rhythm or other physiologic parameter being monitored falls outside of the set alarm limits. Arrhythmia data may trigger an alarm at the time of the event, record at the time of the event, and store the alarmed event. The stored arrhythmia data can be maintained in memory for recall. This arrhythmia history is a valuable tool for patient assessment and treatment. When used appropriately, computerized arrhythmia monitoring can be an invaluable tool that:

- Provides continuous surveillance of all patients
- Alerts caregivers to rhythm changes and arrhythmias
- Is not subject to human fatigue or distraction
- Records an event when it occurs
- Stores arrhythmia information in memory: history and 24 or 72 hour full disclosure
- Reviews events in history

Algorithm Operation

The operation of the arrhythmia algorithm is a 6 step process:

1. Data Acquisition
2. Data Transmission
3. QRS Detection
4. Template Creation
5. Template Comparison
6. Multiple Beat Classification

Step 1 - Data Acquisition

The ECG signal is collected by surface electrodes and digitized by the front-end device, which may be a patient worn transceiver or a bedside monitor. The transceiver digitizes the data at 200 samples per second per vector. Bedside monitors sample at varying rates and output this data to the V-Link, V-Link II, or DT-7000/DT-7001 instrument transceivers. The instrument transceivers convert the sampling rate to 200 samples per second prior to transmitting the data.

Pacemaker detection is performed by the front-end device on the analog signal. A flag is encoded in the digital ECG data stream to indicate where a pacemaker pulse was detected.

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Step 2 - Data Transmission

The Central Station processes the incoming data and uses digital processing to remove any artifact from outside sources of RF (Radio Frequency) interference. The digital data stream received by the Central Station includes the waveform data with encoded pacer flags. The pacer flags are used to indicate where the front end device (ambulatory transceiver or bedside monitor) detected a pacemaker spike. The ambulatory transceiver detects the pacemaker pulse independently in all available leads (I, II, and V for a 5-wire configuration).

Note: Problems with pacemaker detection must be addressed at the front-end device, the user cannot improve the pacemaker detection performance at the Central Station.

Pacemaker filtering is performed to remove the residual pacer artifact from the ECG data. The system blanks a specified number of milliseconds before and after pacer flag by repeating the last ECG sample before the blanking period. The number of milliseconds blanked is determined by the user configurable pacer filter. The filtered 200 sample per second data is passed to the QRS detector. See “Pacemaker Processing” on page 95.

Step 3 - QRS Detection

V-FIB Detection

The first step of arrhythmia detection is QRS and V-FIB detection. The QRS detector is a multi-lead analysis algorithm which detects the presence of QRS complexes or beats. Gross muscle artifact is detected by using a digital bypass filter and will trigger a MUSCLE call. Digital signal processing is employed to reject or reduce the effect of muscle artifact, baseline wander, 50-60 Hz interference, P-waves and T-waves. If no QRS complex is detected for 3-seconds and less than 12.5% of the samples in the 3-second period are bad (RF dropout), an ASYSTOLE is called.

Three other alarms may alert the user to a decrease in signal quality or loss of signal: Check Signal (CHKSIGNAL), Check Lead (CHK LEAD), and No Signal (NO SIGNAL). Check Signal is triggered when no QRS complex is detected for 3-seconds and more than 12.5% of the samples in the 3-second period are bad (RF drop out). Check Lead occurs when one or more ECG leads has a poor connection and/or is causing significant baseline wander. No Signal is called if there are three consecutive 3-second periods which meet the Check Signal criteria.

The underlying waveform is analyzed to detect the presence of Ventricular Fibrillation. Ventricular Fibrillation detection is performed parallel to the QRS processing algorithm. Ventricular Fibrillation is determined by the shape and rate of the rhythm- characteristic of round rolling low-amplitude waves at a rate of 250-300 per minute. When the monitor sees these rapid disorganized ventricular impulses with no discernible normal QRSs, the monitor displays the message V-FIB, initiates a recording and will sound an audible alarm.

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Step 4 - Template Creation

Learning the Reference Beat

The learn "mode" may be initiated by any one of many possible triggers. See "Learn and Relearn Considerations" on page 70. The purpose of the learning period is to identify or learn the patient's dominant beat which is accomplished by identifying the dominant morphology or the most frequently occurring morphology during the learn period. At the beginning of every learn, all previously stored template information is cleared.

Up to six templates are formed during this phase. Each beat is compared to the existing templates and if the beat matches, it is averaged into the template. The learning method uses a complex mathematical method to determine the patient's dominant or "normal" beat. If all beats are identical, learning would complete in 30 beats. However, if the patient has a wide variety of ECG morphologies (rare) or the data is extremely noisy, learning may take as long as 250 beats.

Remember, the learning phase is usually short but may be delayed due to ectopy or artifact occurring during the learn phase. While the monitor is in the learning mode, arrhythmia alarms and trend collection, except for heart rate information, are suspended. Two lethal alarms (ASYSTOLE and V-FIB) and the High and Low Rate alarms will break through during a learn phase. See "Learn and Relearn Considerations" on page 70.

Step 5 - Template Comparison

After the system has learned the patient's "normal" or dominant morphology, and subsequent beats are detected, the system classifies each beat as normal (**N**), aberrant normal (**Q**), supraventricular ectopic (**A**), ventricular (**V**), or unrecognized (**?**).

Template Matching

A template stores information about the shape of a beat. Templates serve as a reference to which all incoming beats will be compared. A simple cross correlation measure is used to determine if a beat matches an existing template. If the beat is not a good match based on this measure, additional measures are made and compared (see feature extraction below).

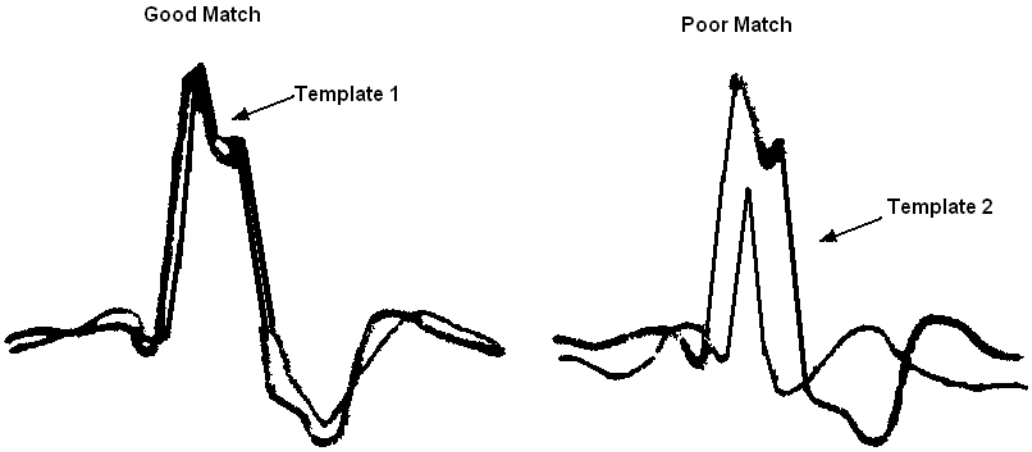

Fig. 17. Template Matching

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Similar to the process used by clinicians to evaluate ECG, the algorithm determines if the patient has previously had that type of beat, if it is occurring more frequently, or if the shape (morphology) has changed. The technical name for this process is template matching.

Feature Extraction

Another aspect of arrhythmia analysis is feature extraction. Similar to template matching, feature extraction compares beats based on a series of characteristics. The algorithms measure a set of features which may include the beat height, width, polarity, and interval. The beat's feature set is then analyzed in relation to the feature set of other saved templates to determine if the beat matches an existing template.

Step 6 - Multiple Beat Classification

Rhythm Analysis

After the beats are classified, the arrhythmia algorithm evaluates sequences of beats for various sequence and/or rate related arrhythmias. As an example, if the algorithm detects alternative normal and ventricular beats for at least six beats, the algorithm calls Bigeminy.

Heart Rate Analysis

The arrhythmia heart rate is calculated as an 6-beat tracked average. All intervals are used for heart rate calculations with the exception of the following:

1. Intervals of 3-seconds or greater
2. Intervals preceding or following unclassified beats ('?' beats)
3. Intervals that are more than +/- 25% different than the current average interval if the longest consecutive bad sample (RF drop out) count is less than 16 samples (80 msec) and the interval bad sample count is less than 37.5% of the interval sample count

The heart rate calculation is as follows:

$$\text{New Heart Rate} = \text{Current Heart Rate} - \frac{\text{Current Heart Rate}}{6} + \frac{\text{Instantaneous Heart Rate}}{6}$$

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Beat Labels

Beat classification labels define the beat. If the features match the reference, then the new beat is classified as NORMAL, or dominant. If they do not match, then the beat is classified as aberrant normal or ventricular. If an abnormal beat is seen repeatedly then it is sent on for further analysis. Beat classifications must precede rhythm classification.

The following annotations are seen in full disclosure:

Table 4 1.05 Arrhythmia Beat Classification Labels

Beat Label	Description
N	Normal or Dominant
Q	Aberrant Normal
q	First Occurrence of Aberrant Normal
A	Premature Normal or Premature Supraventricular Ectopic (SVE)
V	Premature Ventricular Ectopic (PVC)
X	Not Classified Due to Bad Samples (RF drop out) in QRS Region
?	Unknown (Noise or First Occurrence of PVC Morphology)

After beat classification is completed, the rhythm is then classified by the algorithm. The algorithm looks at the beat classifications of the most recent beats and compares the sequences with sequences stored in the monitors memory.

Rhythms are classified as sequence related or normal or dominant. See Table 5.

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Table 5 1.05 Arrhythmia Analysis

Alarm Label	Rhythm	Description
MUSCLE	Muscle	Muscle Artifact
ASYSTOLE	Asystole	No QRS Detected for 3.0 Sec
CHKSIGNAL	Check Signal	Intermittent no signal detected
NO SIGNAL	No Signal	No QRS Detected for 9.0 Sec
V-FIB	Ventricular Fibrillation	Rapid disorganized Ventricular Impulses, no QRS's
V-TACH	Ventricular Tachycardia	Configurable. The number of consecutive PVCs can be set equal to, and between, 3 and 8. The Heart Rate can be set equal to, and between, 100 and 120 BPM. A V-TACH alarm is triggered when the consecutive PVC count is reached AND the heart rate is greater than or equal to the set Heart Rate Value.
V-RUN	Ventricular Run	V-RUN is triggered when the number of consecutive PVCs is greater than 2 and less than the V-TACH configured PVC value (i.e. when the V-TACH is configured at 3 PVCs, the V-RUN alarm is never triggered).
V-RHYTHM	Ventricular Rhythm	V-RHYTHM is triggered when the number of consecutive PVCs is greater than or equal to the V-TACH configured PVC value, but the Heart Rate is less than the V-TACH configured heart rate value.
BIGEMINY	Ventricular Bigeminy	N-PVC-N-PVC-N-PVC Sequence
TRIGEMINY	Ventricular Trigeminy	N-N-PVC-N-N-PVC-N-N-PVC Sequence
COUPLET	Ventricular Couplet	2 Consecutive PVCs
HIGH PVC	High PVC	PVC Count > High PVC Limit
PVC	PVC	Single PVC
SV-TACH	Supraventricular Tachycardia	8 Consecutive SVEs, HR 150 or More
HIGH HR	High Heart Rate	HR Greater than High Rate Limit
LOW HR	Low Hear Rate	HR less than Low Rate Limit
NO ARR	Arrhythmia unable to analyze	No good leads are available for analysis
CHK LEAD	Check Lead	One or more of the ECG leads has a poor connection and/or is causing significant baseline wander
REGULAR	**Normal**	**Dominant Rhythm**

Shape-Related Classification

Shape related arrhythmias occur as single isolated beats and do not form any pattern.

PVC **Single PVC**

Beats are generally classified as premature ventricular beats if they are early and do not match the shape of the dominant QRS complex. PVCs are preceded and followed by normal or aberrant normal beats. If the criteria for Ventricular Bigeminy or Trigeminy is met, these alarms are called instead of the single PVC.

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System Performance

This section includes laser output examples of the majority of the arrhythmia calls detected by the PatientNet System.

Regular; Dominant Rhythm; Beat Annotations - N

Fig. 18. Regular; Dominant Rhythm

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Low HR; Heart Rate less than Low Rate Limit; Beat Annotations - N

Fig. 19. Low HR; Heart Rate less than Low Rate Limit

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High HR; Heart Rate greater than High Rate Limit; Beat Annotations - N

Fig. 20. High HR; Heart Rate greater than High Rate Limit

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High PVC; PVC rate greater than the number of PVCs/minute limit; Beat Annotations - V

Fig. 21. High PVC; PVC rate greater than the number of PVCs/minute limit

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Ventricular Couplet; Beat Annotations - Two Consecutive Vs

Fig. 22. Ventricular Couplet

Ventricular Bigeminy; Beat Annotations - N-V-N-V-N Sequence

Fig. 23. Ventricular Bigeminy

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Ventricular Trigeminy; Beat Annotations - N-N-V-N-N-V Sequence

Fig. 24. Ventricular Trigeminy

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Ventricular Rhythm; HR less than the configured V-TACH value;
Beat Annotations - 3 or more consecutive Vs

Fig. 25. Ventricular Rhythm

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Ventricular Tachycardia; HR greater than or equal to the configured V-TACH value; Beat Annotations - 3 or more consecutive Vs

Fig. 26. Ventricular Tachycardia

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Ventricular Fibrillation; no QRSs;
Beat Annotations - rapid disorganized ventricular impulses

Fig. 27. Ventricular Fibrillation; no QRSs

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Paced Rhythm; Beat Annotations - N or Q

Fig. 28. Paced Rhythm

Lead Off

Fig. 29. Lead Off

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Learn and Relearn Considerations

Immediately upon placing the patient on the system, the arrhythmia analysis software begins a LEARN. During this time, the software is comparing all incoming beats to a reference in order to form a template for that patient's normal QRS complex. During the learn mode, only the alarms for ASYSTOLE and V-FIB are activated. HIGH HR and LOW HR will be generated if the alarms are ON. It is important to regularly review each patient's zoomed in Full Disclosure screen. The annotations that appear should be **N**, for the dominant beat, or **A**, for the premature normal beat. See "Beat Labels" on page 58 for details on annotations.

Rhythm Indicator

The Rhythm Indicator appears as a small green, yellow, or flashing red **R** in the Patient Tile and provides a visual indication of the current beat quality for a given patient. See "Patient Channel Tile" on page 36. When the beat quality value decreases to a set yellow threshold value, which is configurable in the administrator screens, the Rhythm Indictor will appear yellow. Subsequently, when the beat quality value decreases further to a set red threshold value, the indicator will appear red and flash in the Patient Tile. When the beat quality value increases, the Rhythm Indicator is displayed as the appropriate threshold color.

Note: The Rhythm Indicator status is stored in full disclosure and history screens, as well as printed on laser strips. The beat quality percentage is calculated and displayed as a Learned Template Match (LTM) percentage.

Manual Relearning

Use the relearn function under the following conditions:

- a patient's dominant rhythm changes in configuration and type
- leads have been taken off and replaced
- the current learn was performed during an extremely noisy segment.
- when there are significant numbers of Qs without a change in wave morphology.
- a false alarm occurs and the dominant beat is not identified with an "N" in the 24-hour/72-hour full disclosure.
- when the Rhythm Indicator in the Patient Tile turns from green to yellow or red due to a change in wave morphology.

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WARNING: Do not initiate a relearn during an episode of arrhythmia, including ST events, unless it is indicated as stated above. The arrhythmia analysis software may learn an abnormal beat as the patient's Normal if the abnormal beat is the dominant, or most frequently occurring beat, during the learn. If a relearn is accidentally initiated during an episode of arrhythmia, then initiate another manual relearn as soon as it is appropriate to do so.

Note: For patients with a pacemaker, the annotations should be N for the dominant beat or Q for the aberrant normal.

Performing a Learn

1. Press the **Setup** button form the Main screen.
2. Press the **Re-Learn** button from the Patient Settings screen to initiate a relearn.
3. Re-Learn automatically takes place when monitoring resumes after a Smart Alarm.

Automatic Relearning

Relearning occurs automatically after the following conditions:

- patient admit
- the pacer filter blanking period is changed
- the process state is changed from None to Pacer
- the process state is changed from Pacer to ST
- the process state is changed from ST to None
- ST alarm parameters are modified
- ST measurements are modified
- after a local transfer
- on resumption of monitoring after a Smart Alarm
- after alarm state transitions (See table , "Re-learning After Alarm State Transitions," on page 112)

Note: The Central Station automatically initiates a relearn for patients, who are set to Bedside Arrhythmia, when the lead that is being analyzed changes.

Note: For patients with arrhythmia turned off, the Central Station can initiate relearns, but it does not display the relearn text.

WARNING: Make sure that an automatic relearn does not occur during an episode of arrhythmia, including ST events. The arrhythmia analysis software may learn an abnormal beat as the patient's Normal if the abnormal beat is the dominant, or most frequently occurring beat, during the learn. If this does occur, then perform a manual relearn as soon as it is appropriate to do so. See "Manual Relearning" on page 70.

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