



Defensive Monitoring

Troubleshooting Procedures for Nurses

September, 2011



Purpose

This packet is designed to describe the basic principles and procedures for monitoring heart rate, respiration, oxygen saturation and noninvasive blood pressure on the Nihon Kohden Defensive Monitoring System, and to teach the basic troubleshooting thought processes and techniques for each of these parameters.

In addition, the hospital biomedical engineering department is a resource and the Nihon Kohden Technical and Clinical Support teams are available 24 hours a day, 7 days a week at 1-800-325-0283 opt 6.

Learning Objectives

By completing this self-study packet, you will be able to:

1. Discuss how the heart rate values are obtained.
2. Describe the interventions for troubleshooting inaccurate heart rate values and alarms.
3. Discuss how the respiration values are obtained.
4. Describe the interventions for troubleshooting inaccurate respiration values and alarms.
5. Discuss the meaning of oxygen saturation and how the values are obtained.
6. Describe the interventions for troubleshooting inaccurate oxygen saturation values and alarms.
7. Discuss how the noninvasive blood pressure reading is obtained.
8. Describe the interventions for troubleshooting inaccurate noninvasive blood pressure values and alarms.

Introduction

As you know, Defensive Monitoring™ means that your hospital has chosen to monitor a patient's basic vital signs continuously rather than depending on routine vital signs procedures in order to detect subtle changes in your patient's conditions. This Defensive Monitoring™ strategy is accomplished by using the Prefense™ Early Detection and Notification System™ from Nihon Kohden.

To accomplish this, the patient is attached to the NTX transmitter using three ECG electrodes, a finger probe and a blood pressure cuff. The heart rate, the respiratory rate, the oxygen saturation and the blood pressure are monitored in this way. As the vital signs are collected, they are displayed on the NTX transmitter, and then sent to Prefense™ where they are displayed, analyzed and trended, and Prefense will alarm when certain conditions exist. Additionally, these vital signs may be sent to your electronic medical record where you can confirm them for your electronic charting.

In order for the vital signs to be collected, analyzed and reported appropriately, certain nursing interventions are required. This packet reviews the procedures for connecting the patient to the NTX transmitter, reviews how the monitor determines the parameter values and discusses the thought processes and interventions at the patient and on the Prefense™ base station computer during troubleshooting efforts.

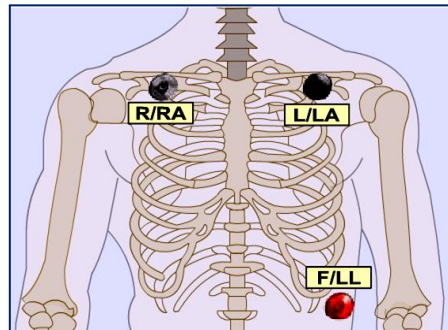


The NTX Transmitter

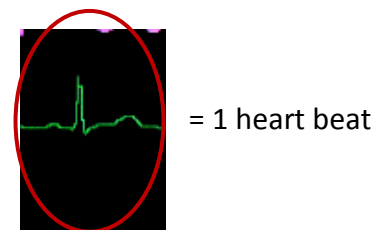
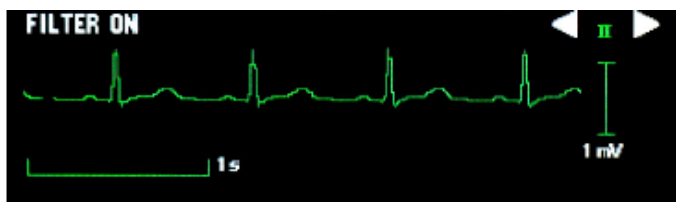
As you know, the heart rate, respiratory rate, oxygen saturation and blood pressure are collected from the patient by attaching him to the NTX transmitter. In order to effectively troubleshoot any issue with inaccurate data collection and/or alarms, one must first understand the mechanism by which the system collects and analyzes the data. This section of the packet will discuss each parameter separately.

Heart Rate

The heart rate is determined by analyzing the electrocardiogram (ECG) waveform that is obtained by placing the three electrodes onto the patient's chest. As a reminder, these electrodes are placed according to the diagram below by removing any hair, rubbing the skin with the dry paper towel or 4x4 to remove the dead skin cells and applying fresh electrodes daily.



The monitor uses the white (RA) and the red (LL) electrodes to capture the ECG signal, with the red electrode (LL) being the primary one that produces the signal (left lower rib-anterior axillary line). These electrodes produce a "lead II" ECG rhythm that is shown on the NTX and the Prefense base station. This "lead" is used because it normally shows the tallest complexes that are the easiest for the monitor to count and analyze. The ECG rhythm looks like this, whereby each tall complex represents the individual heart beat:



The heart rate value on the NTX is obtained by counting the numbers of complexes over the last 8 seconds and this value is updated every 3 seconds. This means that these values are "real-time" values.

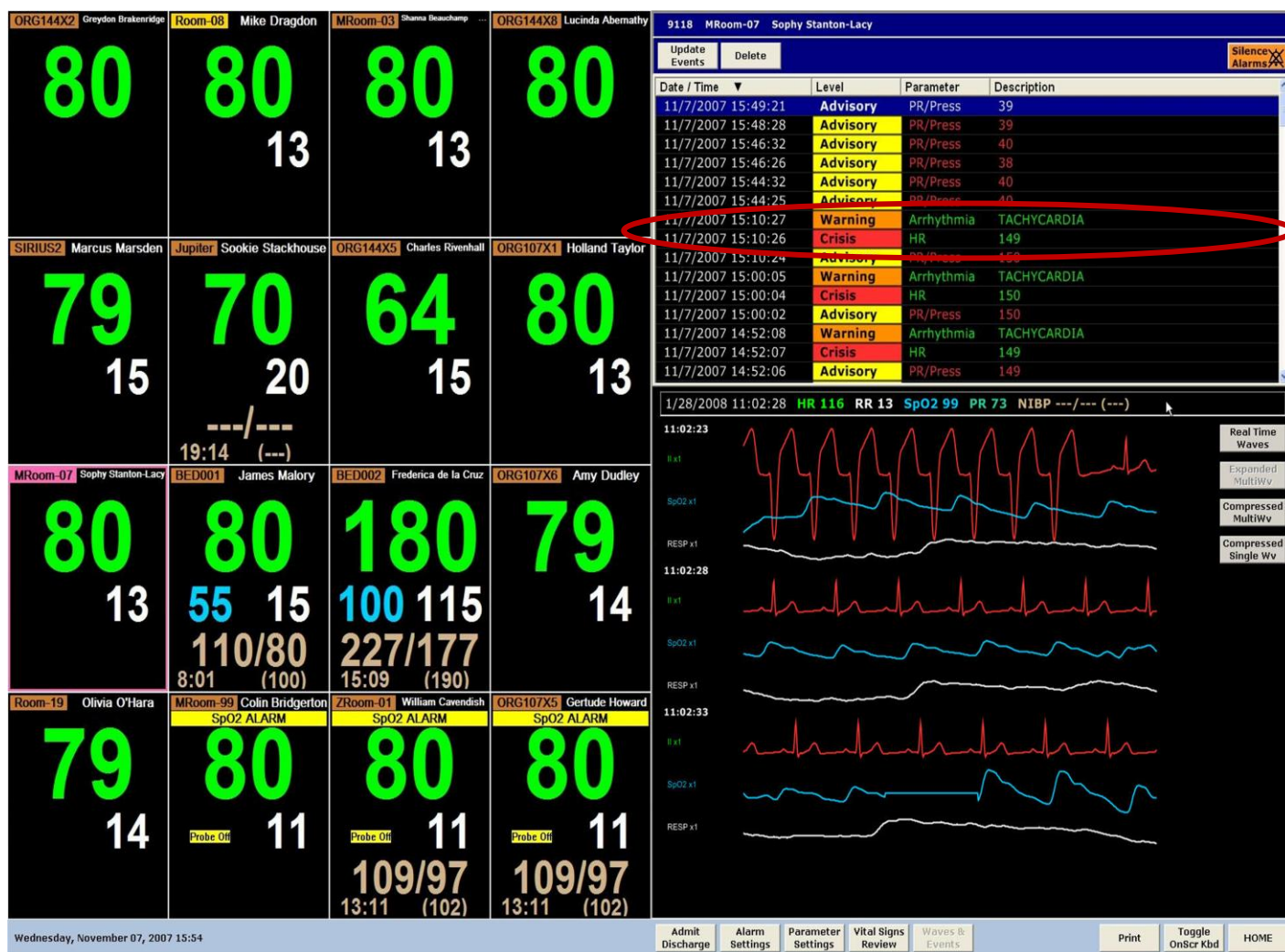
The NTX sends its data through the wireless network over to the Prefense receiver where it is analyzed and then "smoothed" over a 60 second period to remove motion artifacts and other interference that might affect heart rate accuracy to minimize false alarms that are generated by Prefense. This value is updated every three seconds, and reflects the rate at a point in the previous 60 second period. As a result, this value is not "real-time" and will differ from the value on the NTX itself.

Assessing and Troubleshooting Heart Rate Values

When the heart rate meets the alarm limits, it will alarm at the WARNING (bing-bong) level. To prevent additional alarms for this heart rate, change the alarm limit in the ALARM SETTINGS menu on Prefense. Typically, this limit is set to 10 beats/minute higher or lower than the offending heart rate limit, depending on the current heart rate and the patients' condition. The alarms should be set to what you want to know about the value.

In most patients, using standard electrode placement and practices produces satisfactory heart rate counting. But in some patients, the nature of their ECG complexes makes it difficult for the monitor to count the rate accurately, which can produce false heart rate values and alarms. In these instances, there are a few nursing interventions that can help.

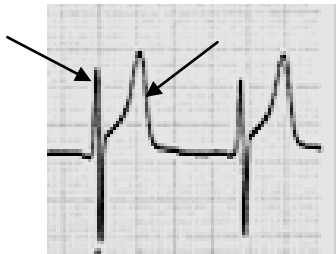
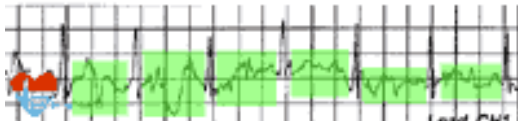

To assess the problem, click on the ALARM in Prefense to display the stored waveforms.

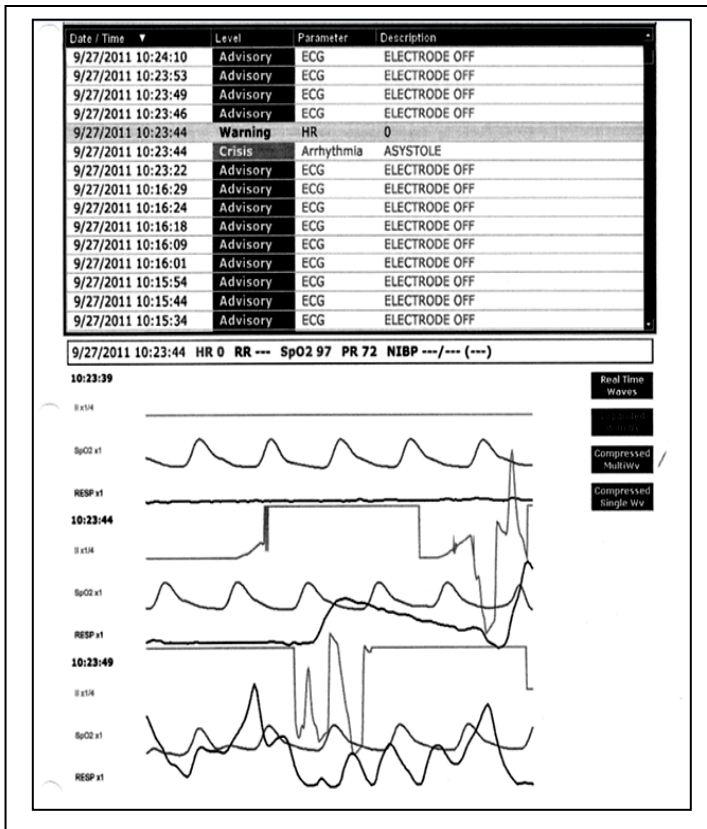


Assess the stored ECG waveform for the following:

1. Is the tracing "clean" and even on the baseline or is it chaotic and wander?
2. Can you clearly see each individual beat?
3. Does the rhythm seem to be faster or slower than "normal" for this patient?
4. Does the individual complex look "normal" or do you see what appears to be extra waves?

Now that you have assessed the tracing, use the table below to determine your next steps:

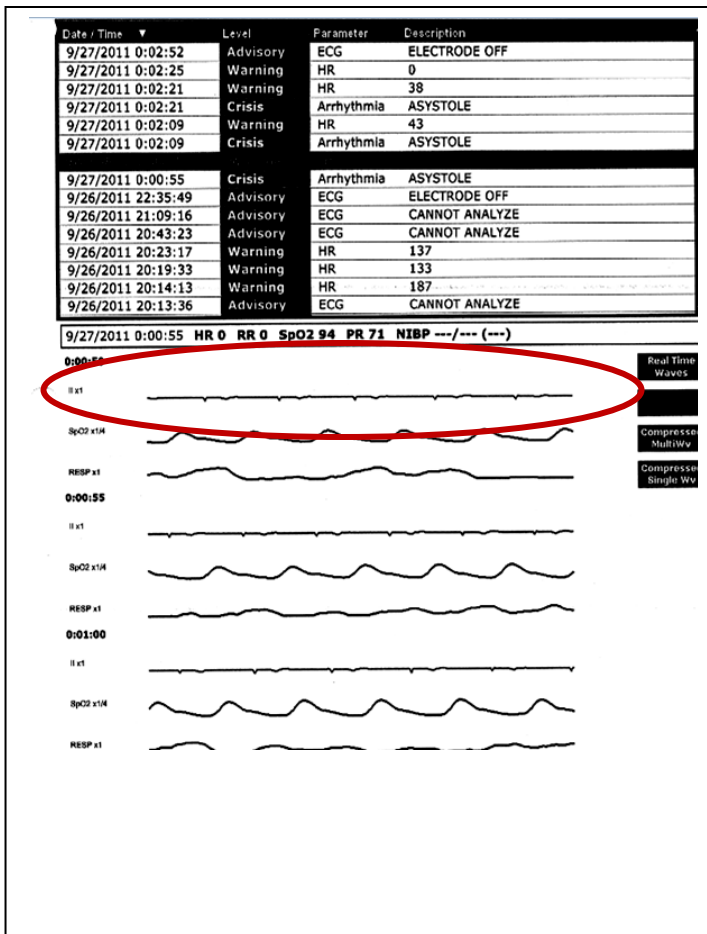
Problem	Possible Cause(s)	Action
The heart rate is not displayed or a CHECK ELECTRODES alarm is occurring	<ul style="list-style-type: none"> • The lead wire block is not inserted securely • The lead wire block is faulty • Excessive NOISE on the ECG waveform is preventing heart rate detection and analysis • An electrode is disconnected 	<ul style="list-style-type: none"> • Insure that the lead wire block is inserted appropriately • Change the lead wire block • Apply new electrodes with good preparation and placement procedures • Apply new electrodes with good preparation and placement procedures
Heart rate is undercounted or alarming asystole when a rhythm exists	The signal is too small to analyze.	Place the red LL electrode higher on the anterior axillary line or even at the 5 th intercostal space at the mid-axillary line.
Heart rate is being double counted	<p>Two portions of the single heart beat wave are being counted as separate beats.</p> 	<ul style="list-style-type: none"> • Insure that electrodes are in the correct positions with the red LL on the anterior axillary line on the left lower rib. <p>OR –</p> <ul style="list-style-type: none"> • Use an alternate electrode placement: Place the white electrode on the left and the black one on the right – leave the red one on the anterior axillary line on the lower rib. This is a “lead III”, which produces a different shaped complex. • Instruct Prefense to “relearn” the heart rate using the LEARN ECG key in the Parameter Settings menu <p>Note: this alternate electrode placement will not detect respiration. Turn respiration OFF in the PARAMETER SETTINGS menu</p>
Prefense is falsely alarming for movement and artifact	<p>Example of EKG Artifacts (artifacts in green)</p>  <p>www.skippinghearts.com</p> <p>Lead wires act as a part of the electrical system and conduct motion to the monitor.</p> <p>Are electrodes fresh and secure?</p> <p>Are electrodes placed correctly?</p>	<ul style="list-style-type: none"> • Change electrodes every 24 hrs • Place electrodes between bones and clear of large muscles (mid clavicular and anterior axillary lines) • Secure lead wires with stress loops to prevent movement of the lead wire on the electrode as the patient moves 
Difficulty in monitoring a patient with a pacemaker	The pace maker may not be detected with the pace detection enabled on Prefense.	Turn Pacing detection to OFF in the Parameter Settings menu



How would you assess this HR 0 alarm?

- There are multiple ELECTRODE OFF alarms before and after this HR 0 alarm.
- The top ECG tracing is in fact a straight line which becomes artifact and then a straight line again.
- The respiration waveform is also flat.
- The asystole alarm is associated with the HR 0 alarm and means the same thing

This is an electrode/lead wire problem, where an electrode is making intermittent contact with the skin. Also, the lead wire(s) may be pulling on the electrodes. Try good skin prep and fresh electrodes with stress loops on the lead wires.

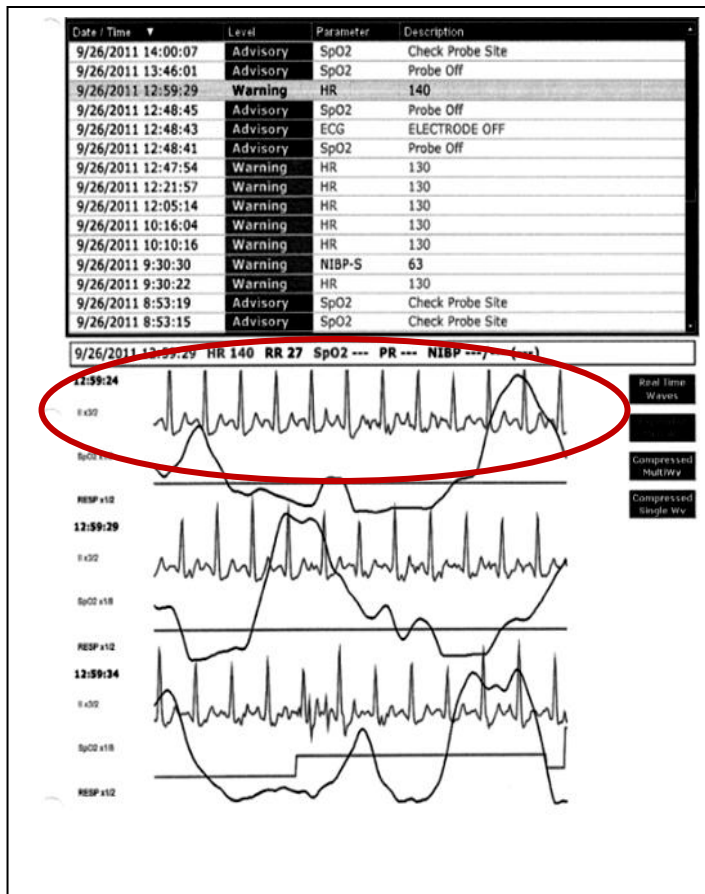


How would you assess this HR 0 alarm?

- There are multiple ELECTRODE OFF alarms before and CANNOT ANALYZE alarms after this HR 0 alarm.
- The ECG tracing is almost a straight line with very tiny complexes.
- The asystole alarm is associated with the HR 0 alarm and means the same thing

This is an electrode placement problem. Remember that the tracing is coming from the right arm and left leg electrodes, with the left leg (red one) being the key.

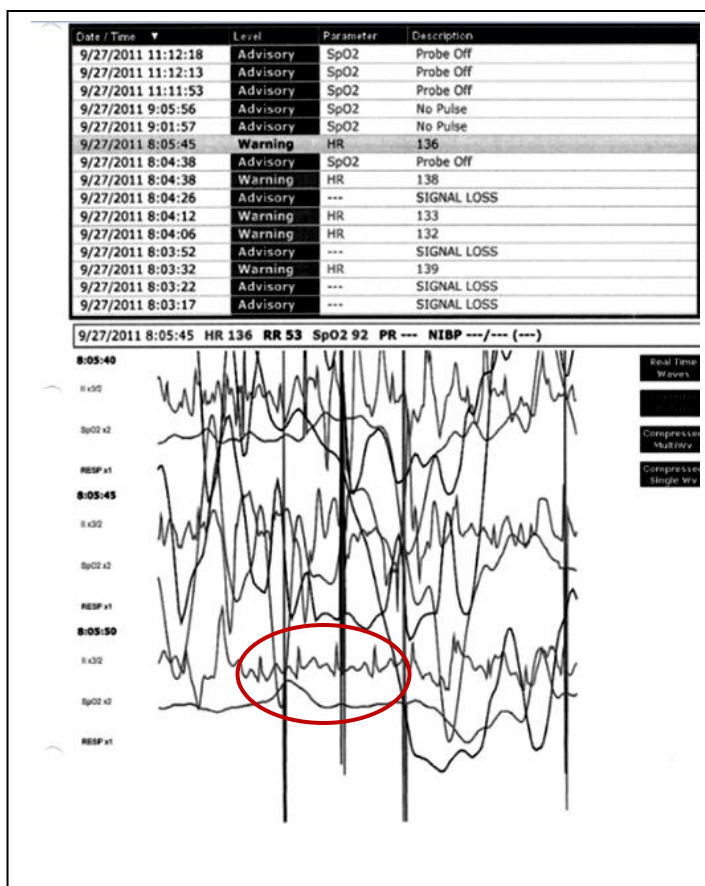
Apply fresh electrodes with the left leg (red) electrode on the left lower rib on the anterior axillary line.



How would you assess this HR 140 alarm?

- The ECG tracing shows a fairly even baseline.
- The complexes are spaced closely together indicating a higher heart rate.

This is a true alarm. It may be necessary to increase the alarm limit to 145 to prevent repeating this alarm while you are assessing and treating the patient.



How would you assess this HR 136 alarm?

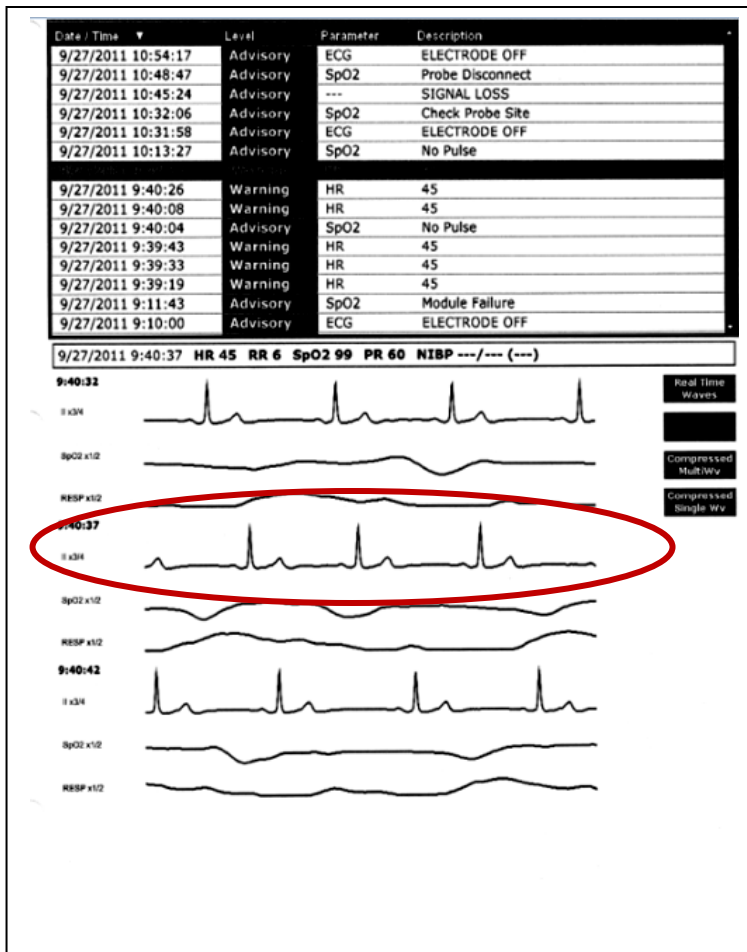
- The ECG tracing shows a chaotic and wandering baseline.
- It's difficult to identify the ECG complexes, but when you can see them (third section), they are spaced closely together indicating a higher heart rate.
- The respiration and SpO2 waveforms are chaotic as well.

This is a true HR alarm, but this scenario indicates excessive patient motion with poor electrode and SpO2 probe contact.

For the electrode problem, try good skin prep and fresh electrodes with stress loops.



For the SpO2 problem, insure that the probe is on the non-dominant hand and secure the wire with tape.



How would you assess this HR 45 alarm?

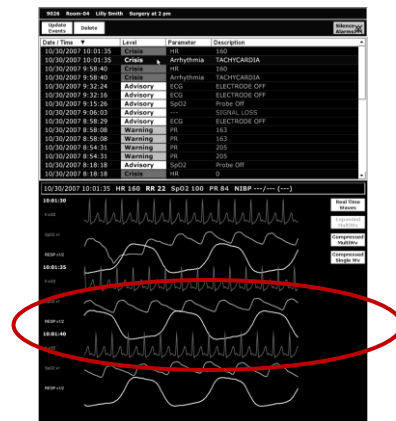
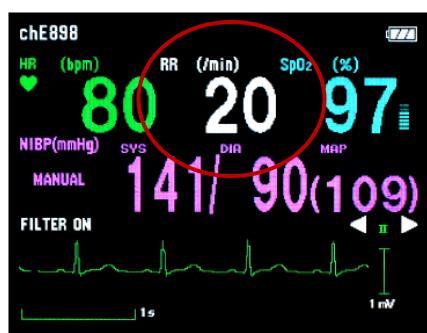
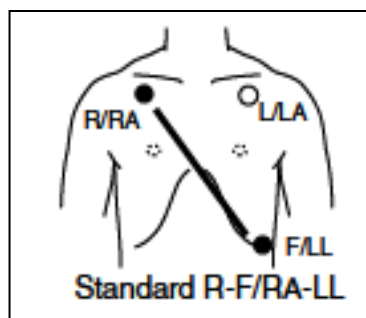
- The ECG tracing shows an even and “clean” baseline.
- The complexes are spaced far apart indicating a lower heart rate.

This is a true HR alarm. It may be necessary to decrease the alarm limit to 40 to prevent repeating this alarm while you are assessing and treating the patient.

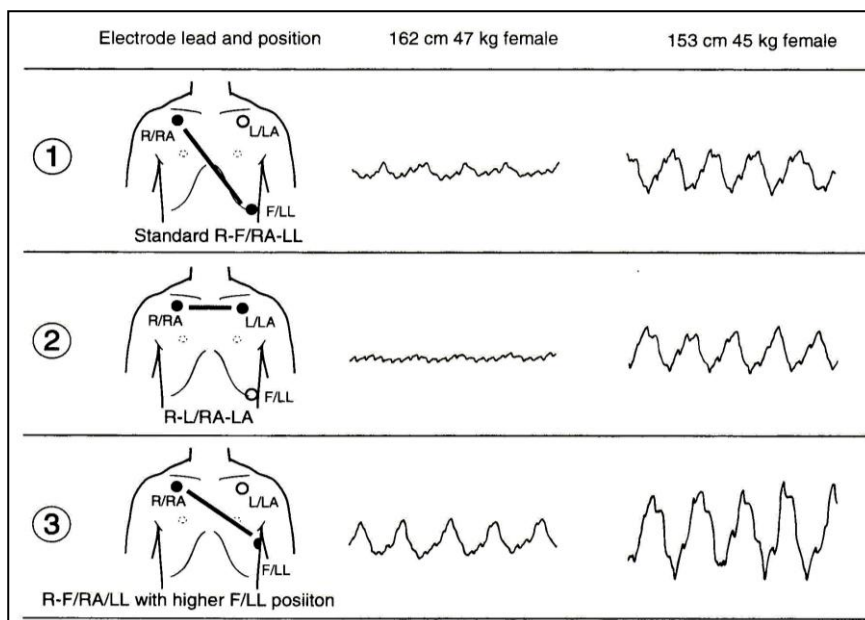
Respiration Monitoring

In addition to the heart rate monitoring that we've discussed above, the NTX detects respiration through the right arm (white) and left leg (red) electrodes. By placing the red LL electrode on the lower rib at the anterior axillary line, you will see a good respiration lead, in addition to the heart rate on most patients.

As the patient breathes, the monitor detects a change in the electrical current and it displays a waveform on the screen. When the chest rises, the waveform rises. When it falls, the waveform falls. A respiratory rate per-minute is displayed on the NTX and on Prefense, and it is trended as well.



To have good respiration detection, you must have fresh electrodes that are positioned so that the lungs can expand between the white and red lead wires. If the patient's respirations are not being detected, insuring that the electrodes are moist and repositioning them can help. The chart below illustrates the differences in the waveform with different positions on different sizes of females so sometimes standard placement is not adequate for larger patients.



Troubleshooting Respiration

To improve the respiration detection on larger patients, it might help to place the red LL electrode on the 5th intercostal space, mid-axillary line. It may also be necessary to move the white RA electrode a couple of inches lower on the right chest. Remember to prepare the skin and use fresh electrodes as the first step in respiration troubleshooting.



Oxygen Saturation - SpO2

The NTX monitors oxygen saturation continuously using an infrared finger sensor that attaches to the bottom of the transmitter. These probes may be reusable or disposable.

The SpO2 value and a pulse indicator are displayed on the NTX and the SpO2 and pulse rate values and a waveform are displayed and trended on Prefense. There should be a pulse wave following each ECG complex.

What is oxygen saturation? (<http://www.pulseox.info/pulseox/what2.htm>)

Oxygen is carried in the blood attached to hemoglobin molecules. Oxygen saturation is a measure of how much oxygen the blood is carrying as a percentage of the maximum it could carry. One hemoglobin molecule can carry a maximum of four molecules of oxygen, so if a hemoglobin molecule is carrying three molecules of oxygen; it is carrying 3/4 or 75% of the maximum amount of oxygen it could carry.

One hundred hemoglobin molecules could together carry a maximum of 400 (100 x 4) oxygen molecules. If these 100 hemoglobin molecules were carrying 380 oxygen molecules they would be carrying (380 / 400) x 100 = 95% of the maximum number of oxygen molecules that could carry and so together would be 95% saturated. A "normal" SpO2 for an adult is between 95-99%.

The color of blood varies depending on how much oxygen it contains. A pulse oximeter shines two beams of light through a finger (or earlobe etc.); one beam is red light (which you can see when a pulse oximeter is used), and one is infrared light (which you don't see). These two beams of light can let the pulse oximeter detect what color the arterial blood is and it can then work out the oxygen saturation. However there are lots of other bits of a finger which will absorb light (such as *venous* blood, bone, skin, muscle etc.), so to work out the color of the arterial blood, a pulse oximeter looks for the slight change in the overall color caused by a beat of the heart pushing arterial blood into the finger.

Troubleshooting SpO2

Problem	Possible Cause(s)	Action
SpO2 – Probe Off Alarm	The probe is off the finger	Replace the probe, or if SpO2 monitoring is not required, remove probe from the NTX in order to stop the monitoring and silence alarm at Prefense
SpO2 – No pulse Alarm	Incorrect probe placement will prevent monitoring. The probe is not making good contact with finger or the pulse is weak in that digit	<ul style="list-style-type: none"> Secure probe with the lights directly across from each other and reinforce the probe wire with tape Move the probe to another finger Place the hand under a cover to warm it
SpO2 – NOISE Alarm or no value	Finger motion can cause interference. The ring or small fingers produce the least amount of interference in this area – the index finger produces the most and it is the most uncomfortable for the patient since they must use their hands for their ADL's.	<ul style="list-style-type: none"> Secure probe with the lights directly across from each other and reinforce the probe wire with tape Change the location of the finger probe every 4 to 8 hours and to inspect the site for changes in circulation due to the pressure of the probe
SpO2 value is lower than expected	The probe is not making good contact with finger, the pulse is weak or motion or ambient light is interfering	<ul style="list-style-type: none"> Insure good probe placement Insure adequate pulse exists Place the hand under a cover to block light

9/27/2011 11:51:10	Advisory	ECG	ELECTRODE OFF
9/27/2011 10:14:07	Advisory	ECG	ELECTRODE OFF
9/27/2011 10:08:11	Advisory	SpO2	Noise
9/27/2011 10:03:35	Advisory	SpO2	Probe Off
9/27/2011 6:27:23	Warning	SpO2	89
9/27/2011 6:11:29	Warning	SpO2	89
9/27/2011 4:13:10	Warning	SpO2	89
9/27/2011 4:09:05	Warning	SpO2	89
9/27/2011 4:05:43	Warning	SpO2	89
9/27/2011 4:05:25	Advisory	SpO2	Probe Off
9/27/2011 4:03:59	Warning	SpO2	89
9/27/2011 3:55:33	Warning	SpO2	88
9/27/2011 3:51:40	Warning	SpO2	88

9/27/2011 11:52:56 HR 130 RR 3 SpO2 94 PR 79 NIBP ---/--- (---)

11:52:51

II x3/4

SpO2 x1/2

RESP x1/2

11:52:56

II x3/4

SpO2 x1/2

RESP x1/2

11:53:01

II x3/4

SpO2 x1/2

Date / Time	Level	Parameter	Description
9/27/2011 10:54:17	Advisory	ECG	ELECTRODE OFF
9/27/2011 10:48:47	Advisory	SpO2	Probe Disconnect
9/27/2011 10:45:24	Advisory	---	SIGNAL LOSS
9/27/2011 10:32:06	Advisory	SpO2	Check Probe Site
9/27/2011 10:31:58	Advisory	ECG	ELECTRODE OFF
9/27/2011 10:13:27	Advisory	SpO2	No Pulse
9/27/2011 9:40:26	Warning	HR	45
9/27/2011 9:40:08	Warning	HR	45
9/27/2011 9:40:04	Advisory	SpO2	No Pulse
9/27/2011 9:39:43	Warning	HR	45
9/27/2011 9:39:33	Warning	HR	45
9/27/2011 9:39:19	Warning	HR	45
9/27/2011 9:11:43	Advisory	SpO2	Module Failure
9/27/2011 9:10:00	Advisory	ECG	ELECTRODE OFF

9/27/2011 9:40:37 HR 45 RR 6 SpO2 99 PR 60 NIBP ---/--- (---)

9:40:32

II x3/4

SpO2 x1/2

RESP x1/2

9:40:37

II x3/4

SpO2 x1/2

RESP x1/2

9:40:42

II x3/4

SpO2 x1/2

RESP x1/2

How would you assess this SpO2 waveform and SpO2 alarms?

- The SpO2 tracing shows an even and "clean" baseline.
- The pulses follow the ECG beats indicating proper probe placement.
- There are multiple SpO2 alarms for a 88-89 value.

This is a good SpO2 waveform that should produce accurate SpO2 values. Decrease the alarm limit to 87 if the patient is tolerating this 88-89 level.

How would you assess this SpO2 waveform?

- The SpO2 waveform shows a nearly flat baseline indicating inadequate probe placement.
- There are multiple SpO2 NO PULSE alarms

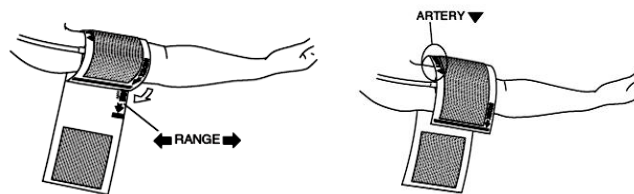
Insure that the probe is on the non-dominant hand and positioned with the lights directly across from each other on the nail bed. Secure the wire with tape.

Non-Invasive Blood Pressure (NIBP)

The NTX uses the occlusive-oscillometric method to measure systolic, diastolic and mean non-invasive blood pressure. The Nihon Kohden NIBP algorithm measures changes in the amplitude pattern of pulsatile oscillations (vibrations) in the artery as it is reduced from above systolic (inflation) to below diastolic (complete deflation) pressure.

The systolic pressure is the pressure at which the pulsatile oscillation suddenly increases during cuff deflation (pulse returns), and the diastolic pressure is the pressure at which the pulsatile oscillation suddenly decreases (pulse stabilizes). The mean blood pressure is the point where maximum pulsatile oscillation occurs.

Cuff selection should be based on the size of the extremity. To obtain accurate readings, select a cuff that is wide enough to wrap the upper arm and keep the cuff reference markers within the range that is indicated on the inside of the cuff, and insure that the artery marker is positioned over the brachial artery.



Troubleshooting NIBP

Use the following table to determine the nursing intervention based on the cause of the problem.

Problem	Possible Cause(s)	Action
NIBP – taking extra readings	The INTERVALS are set on the NTX	Select the MANUAL interval on the NTX to turn off the cycles
NIBP – Check cuff/Hose Alarm	The NTX attempted a reading without the hose in place	Check the INTERVAL and insure that it is not set without the hose/cuff on the patient
NIBP – Cannot Measure Alarm	The NTX was unable to detect a reading – could be due to movement, a weak pulse or a cuff that is in the incorrect position.	<ul style="list-style-type: none"> • Reposition the cuff and retake the pressure • Ask the patient to lie still during readings
NIBP – Did not take automatic readings as set	The START/STOP key MUST be pressed to activate the intervals once they are set. STANDBY appears on the screen until the cycles are activated, and then a progress bar appears to show time between readings	Press the START/STOP key after setting the INTERVALS to activate the automatic cycles
NIBP values different from expected.	Inappropriate cuff size and/or arm positioning will result in inaccurate NIBP readings. Cuffs that are too large or the arm positioned above the level of the heart will produce false low readings, and cuffs that are too small or the arm positioned below the level of the heart will produce false high readings. Inaccurate readings may occur during movement as the muscle action may be incorrectly interpreted	<ul style="list-style-type: none"> • Reposition cuff and retake pressure • Ask patient to lie still during readings • When readings are questioned, use a manual BP reading to validate the results.

Conclusion

The NTX transmitter, as a part of the Defensive Monitoring system, continuously monitors the patient's heart rate and rhythm, and respiratory status through impedance respiration and pulse oximetry. By offering noninvasive blood pressure capability, the clinician has another physiologic parameter to add to the clinical data set for the assessment.

The clinician's responsibility with this system is to insure that this data is accurate and valid, which is accomplished by using the proper monitoring and alarm control procedures and prompt interventions based on your nursing assessments. It is imperative that caregivers pay particular attention to the preparation and maintenance procedures for this technology. This includes: 1) practicing appropriate electrode placement and skin preparation procedures, 2) using proper SpO2 probe and cuff procedures, and 3) intervening appropriately based on the recommendations for the issues at hand.

You will facilitate improved outcomes during your patient's hospital stay by maintaining the monitoring system appropriately, by acquiring the best information that you can, and by responding when the system alerts you to changes as they occur.

References

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- Drew et al, (2005) Practice Standards for Electrocardiographic Monitoring in Hospital Settings: An American Heart Association Scientific Statement From the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young. *AHA Scientific Statement*. Journal of cardiovascular nursing.
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