About Non-Invasive Blood Pressure

Application Note

Introduction

This application note discusses:

- non-invasive (NBP) blood pressure measurements and techniques.
- how the HeartStart MRx and XL+ use the oscillometric method to measure blood pressure.
- how to reduce errors and obtain an accurate NBP measurement.

PHILIPS

NBP Techniques

Non-invasive blood pressure measurements are quick and simple to do, and cause minimum stress to the patient.

Auscultatory (Manual Cuff)

This technique uses a sphygmomanometer and an occluding cuff and a sound detector or a stethoscope over the occluded artery to detect the sound which is emitted as the cuff is deflated. The cuff pressure at which the sound is first emitted indicates the systolic pressure. When the sound disappears, or when the sound quality changes, the cuff pressure is approximately equal to the diastolic pressure.

Auscultation Assisted with Doppler Flow Detectors

This technique requires a sphygmomanometer and a handheld Doppler device. The pulse detector is placed over the brachial or radial artery distal to the cuff and the characteristic hushing sound (shhh, shhh, shhh) signifying blood flow and vascular motion, is listened for as cuff pressure is reduced. The pressure at which the first hushing sound is heard is recorded as the systolic pressure. The hushing sounds continue as long as the device is held over the open artery.

Oscillometric

Oscillometric devices measure the amplitude of pressure changes in the occluding cuff as the cuff is deflated from above systolic pressure. The amplitude suddenly increases as the pulse breaks through the occlusion in the artery. The pressure at which this occurs is very close to the systolic pressure. As the cuff pressure is decreased further, the pulsations increase in amplitude, reach a maximum (which approximates to the mean pressure), and then diminish rapidly. The index of diastolic pressure is taken where this rapid transition begins.

How NBP Works in the HeartStart MRx and XL+

The HeartStart MRx and XL+ are equipped with the ADVANTAGE® oscillometric non-invasive blood pressure measuring system from SunTech Medical. The HeartStart MRx and XL+ measure blood pressure for both adult and pediatric (or infant/child) patients using the oscillometric method. Initial cuff inflation pressure is based on the configured patient type: adult or pediatric (or infant/child). Measurement ranges and default alarms can also be adjusted when the patient category is changed. Systolic, diastolic, and mean measurements are provided, and alarms are available to alert the clinician to changes in the patient's condition. NBP measurements can be taken while in Monitor, Pacer, or Manual Defib Modes. Accurate readings can be taken at heart rates of 40 to 200 beats per minute, systolic pressures of 40 to 260 mmHg and diastolic pressures of 20 to 200 mmHg.

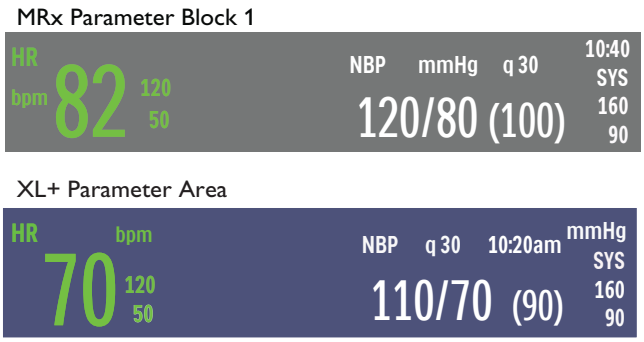
NBP measurements can be taken:

- *Manually:* One measurement is taken each time the Start NBP soft key is pressed.
- *Automatically:* The measurement is repeated at the specified interval of minutes from the time the Start NBP key is pressed. Additional manual measurements can be taken without affecting the automatic measurement schedule by pressing the Start NBP soft key.

While an NBP measurement is in progress, the current cuff pressure is displayed in the MRx's Parameter Block 1 and the XL+'s parameter area. Once the measurement is complete, the values for systolic, diastolic, and mean pressure are displayed, along with the measurement schedule (manual or automatic intervals) and a time stamp. (See Figure 1.)

If NBP alarms are enabled, alarm limits appear next to the NBP value and the alarm source (systolic, diastolic, or mean) is displayed above the NBP alarm limits. If alarms are off, the **Alarms Off** symbol replaces the limits.

Figure 1 **NBP Values**



How the NBP Algorithm Works

The first time an NBP measurement is taken, the cuff's initial inflation pressure is 160 mmHg (adult) or 120 mmHg (pediatric or infant/child). As the cuff starts to deflate, pulsatile flow in the form of oscillometric pulses begins as pressure on the brachial artery is diminished. As cuff deflation continues, the amplitude of these oscillometric pulses increases until a maximum amplitude is achieved which correlates with mean arterial pressure (MAP). The oscillometric pulse amplitudes then begin to decrease as the remaining cuff pressure is released. As the cuff deflates, pulsatile flow in the form of oscillometric pulses (heart beats) is analyzed. When two "qualified" pulses are acquired, the cuff is deflated to the next step (step time-out can occur under certain conditions). An oscillometric curve is created from all of the oscillometric pulses. The curve is then used to calculate the systolic, diastolic, and mean values.

The safety circuit pressure time-out is 180 seconds with automatic cuff overpressure detection at 300 mmHg in both adult and pediatric (or infant/child) modes.

NOTE: For elevated systolic blood pressure, the device will re-inflate, as needed, to a maximum of 280 mmHg.

Motion Tolerance

The NBP module is motion tolerant — it has the ability to obtain a successful blood pressure reading during typical patient activity as well as during patient transport conditions. Greater motion tolerance means fewer cuff inflation cycles and faster clinical results.

Maintaining the NBP module

The NBP module requires calibration every year by a qualified service person. The HeartStart MRx's and XL+'s Service Mode screens provide step-by-step instructions for the calibration procedure.

How to Reduce Errors and Obtain an Accurate NBP Measurement

Measurement Errors

Like any measurement, the manual cuff technique and the oscillometric technique are subject to errors. The major factors which influence the accuracy of each technique are listed in Table 1.

Reducing Errors

Cuff Size

A very important factor for accuracy is the selection of the correct cuff size. The AHA recommends that the width of the cuff should be 40% of upper arm circumference. Most manufacturers have an indicator on their cuffs which allows the staff to see whether they are using the proper size during attachment to the patient's arm or leg. (For the best results, Philips' cuffs should be used. They are the only cuffs that have been verified for use with the HeartStart MRx and XL+.)

Table 1 **Major Sources of Errors Affecting the Accuracy of NBP Measurements**

Auscultatory Cuff Technique	Oscillometric Technique
Too rapid deflation of the cuff [a]	
Misinterpretation of Korotkoff sounds [a]	
Incorrect cuff size [a]	Incorrect cuff size [a]
Incorrect cuff application [a]	Incorrect cuff application [a]
Calcification of the artery [b]	
Arrhythmias [b]	Arrhythmias [b]
Rapid changes in pressure [b]	Rapid changes in pressure [b]
Operator's hearing acuity [a]	Patient movement [b] (twitching, shivering, etc.)
Pressure waveform with high spikes [b] (high dp/dt)	
Cuff not at heart level [a]	Cuff not at heart level [a]

a. Technical sources of errors which can be minimized by the operator.

b. Clinical or physiological sources of errors which cannot be minimized by the operator.

Cuff Placement

Correct placement of the cuff over the artery is critical for blood pressure measurements. The cuff should be at heart level, or a correction factor added for the height difference. Ideally, the lower edge of the cuff should be located approximately 2 cm above the antecubital fossa (bend of the elbow, see Figure 2).

Figure 2 **Cuff Placement**

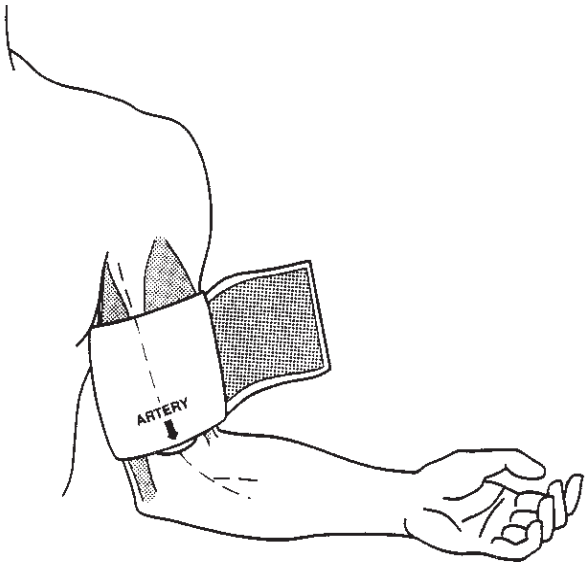


Table 2 shows some reasons how incorrect cuff size and placement can cause false high or low readings.

Table 2 **Incorrect Cuff Size and Placement Issues** [1]

Problem	Cause	Rationale
False high reading	Cuff too small	Small cuff does not adequately disperse the pressure over the arterial surface
	Cuff not centered over the brachial artery	More external pressure is needed to compress the artery
	Cuff not applied snugly	Uneven and slow inflation results in varying tissue compression
	Arm below heart level	Hydrostatic pressure imposed by weight of intra-arterial blood column above site of auscultation additive to arterial pressure. Reposition arm to heart level
False low reading	Cuff too large	Pressure is spread over too large an area and produces a damping effect on the oscillometric pulses
	Arm above heart level	Hydrostatic pressure in the elevated arm causes resistance to pressure generated by the heart

Clinical Considerations for NBP Monitoring

Keep in mind the following considerations when monitoring blood pressure:

- Do not perform non-invasive blood pressure measurements on patients with sickle-cell disease, lymphedema, or any condition where skin damage has occurred or is expected.
- Use clinical judgement to decide whether or not to perform automatic blood pressure measurements on every patient, such as those with severe blood clotting disorders, because of hematoma in the limb or lymphedema.

- Prolonged series of non-invasive blood pressure measurements in automatic mode may be associated with purpura, ischemia, and neuropathy in the limb wearing the cuff. When monitoring a patient, remove the cuff and examine the extremities of the limb frequently for normal color, warmth, and sensitivity. If any abnormality is observed, stop the blood pressure measurements immediately.

Summary

Non-invasive blood pressure measurements are easily tolerated by patients and contribute to reduced patient safety risks. Developed for transport situations, the HeartStart MRx's and XL+'s NBP module employs the oscillometric method to accurately and reliably measure mean arterial pressure and calculate systolic and diastolic pressure.

Reference

1 Darovic, Gloria Oblouk. *Hemodynamic Monitoring: Invasive and Non-Invasive Clinical Application,* 2nd edition. Philadelphia: W.B. Saunders Company, 1995.

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