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Noninvasive Blood Pressure

Clinical Reference Guide

Because you care

Table of Contents

Introduction

Taking a patient's blood pressure is one of the first clinical competencies nurses acquire. Because this fundamental procedure is routine, it may seem that there is nothing left to learn. However, because there are many indirect (noninvasive) blood pressure devices in use, and they are frequently compared with direct arterial valves, it is important to understand the differences and benefits of each approach. As simple as taking a patient's blood pressure may seem, it can be prone to error and misinterpretation, if not applied and setup correctly.

Principles of Noninvasive (Indirect) Blood Pressure Monitoring

Arterial blood pressure is created by pulsatile blood flow during the ejection phase of the cardiac cycle. Left ventricular ejection initiates a pressure wave that precedes the actual flow of arterial blood, creating the pulses we palpate.

- **Systolic blood pressure** represents ventricular ejection and the arterial system's response to it
- **Diastolic pressure** represents the resting phase of the cardiac cycle
- **Pulse pressure** is the difference between the two
- **Mean arterial pressure**, also called the MAP, represents the average driving force for movement of blood in the arterial system throughout the cardiac cycle[1]

Auscultatory Method

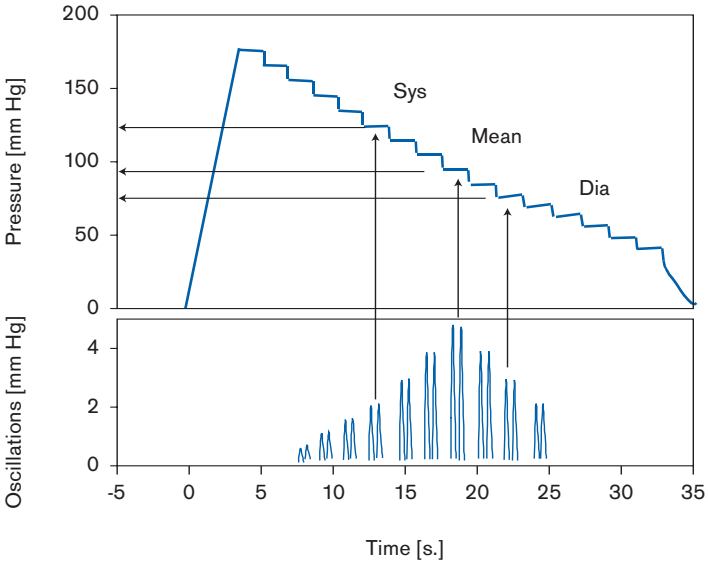
The auscultatory method is the most common means of measuring blood pressure. Compressing the brachial artery with an inflated cuff creates turbulence and arterial wall vibrations – making sounds known as Korotkoff, which can be heard with a stethoscope. The onset of Korotkoff sounds denotes the systolic pressure, while the complete disappearance of Korotkoff sounds signifies the diastolic pressure.[2] It is important to note that in the auscultatory method, the mean pressure cannot be directly measured.

Oscillometric Method

Automated noninvasive measurement devices have been around since the early 1970s and technological advancements have dramatically improved their accuracy in critically ill patients over the years. Infinity® patient monitors use the oscillometric method of measuring noninvasive blood

pressure (NBP). The blood pressure cuff is inflated above the patient's systolic pressure, occluding blood flow through the artery. As the pressure in the cuff is reduced, the blood pressure pulses within the artery distend the soft tissues of the limb. The tiny fluctuations in arm circumference cause pressure oscillations in the cuff, which can be sensed by transducers within the monitor.

The maximum oscillations indicate the mean arterial pressure, which the system detects first. In Dräger Medical Infinity patient monitors, the systolic and diastolic pressures are *identified* when the oscillations are 85% and 55% of the maximum oscillation.



Factors That Can Affect Performance and Accuracy

Infinity monitors are rigorously tested to ensure that they perform accurately. The current NBP accuracy exceeds the Association for the Advancement of Medical Instrumentation published standard (ANSI/AAMI SP10-2002), by which manual, electronic or automated sphygmomanometers are compared to invasive blood pressure measured at the aortic arch.

It is important to understand the limitations of *all* NBP devices that use the oscillometric method. Since oscillometric devices derive blood pressures from vibrations in the vessel walls – as opposed to arterial lines measuring pressures directly – certain conditions may affect accuracy. The most frequent of these is excessive patient movement.

It is sometimes difficult to get accurate readings on patients who are experiencing profound seizure activity, have Parkinson-type tremors, or are shivering. Neonates, infants and uncooperative adults have a tendency to move excessively during cuff inflation. In addition, external vibrations – such as those that occur if the cuff is bumped – may also alter readings.

Low perfusion states can also be problematic because they produce arterial wall oscillations that are often too weak for the system to detect. Noninvasive pressures taken on patients with significant hypotension, low pulse pressures and poor peripheral blood flow may result in erroneous readings. In severe cases, the device may be unable to obtain a reading at all. In these situations, clinicians recommend direct blood pressure measurements over indirect for patients in severe states of shock or who are very unstable.[2]

Obtaining Consistent Results

To optimize your noninvasive blood pressure readings, follow these recommendations:

1. The factor that affects measurement accuracy most is proper cuff size. Small cuffs or loosely applied cuffs tend to overestimate pressure, while large cuffs tend to underestimate it.

2. To select a proper cuff size, follow the American Heart Association recommendations. Use a cuff that has a width 40% larger than the limb circumference or 2/3 the length of the upper arm (length equal to 80% of arm circumference). The inflatable part of the cuff should encircle 50-80% of the extremity. When in doubt, always use a larger cuff.

3. Do not apply the cuff too tightly or too loosely. The cuff is applied properly if you can insert one finger between the patient's arm and the cuff. Squeeze all remaining air out of the cuff before obtaining a new reading.

4. Always use the accessories that are recommended by the manufacturer. The system has been calibrated and checked for accuracy using these accessories.

5. Connect the hose and cuff securely, checking for damage or kinks that may cause inaccurate readings. Make sure all connections are tight.

6. Position the cuff at heart level to obtain the most accurate measurements, as compared to the aortic root pressure. If this is not possible, you can adjust the readings. For every 10cm above the heart, add 8 mm Hg. For every 10cm below the heart, subtract 8 mm Hg.

7. Position the cuff so that the artery ↓ marker is over the artery and pointing toward the hand or foot.

Frequently Asked Questions

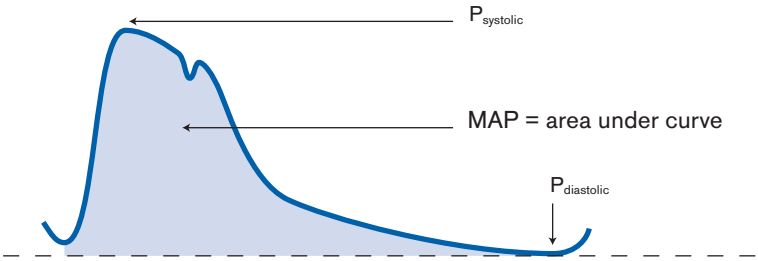
Why does the noninvasive pressure differ from the arterial line pressure?
Cuff pressures are based on flow induced vibrations, and direct arterial line measurements are based on pressure. No absolute relationship exists between these two phenomenons because they follow different laws of physics and physiology. Conditions such as hypotension and varying systemic vascular resistance (SVR) affect the correlation between the two methods. For example, vasoconstriction will yield lower indirect measurements, whereas a low SVR will result in a higher NBP.[3] Research suggests that it is inappropriate to simultaneously use both techniques.[4] Instead, take all factors into consideration and use the most clinically appropriate measurement method.

What does "stepped deflation" mean?
The monitor determines the patient's blood pressure during deflation of the cuff. Stepped deflation is when the air is bled out of the cuff in short intervals, or steps. This is compared to linear deflation, where the air is bled out of the cuff in a continuous stream. Stepped deflation has proven to be a more effective method, especially in the presence of motion artifact. If necessary, a pressure can be held for a variable length of time during motion so the system can better detect oscillations.

Stepped deflation has also been shown in studies to be a better method in low perfusion or hypotensive patients where the detected oscillations may be too small for linear deflation. In addition, the sounds generated from these small changes in pressure may be inaudible using the auscultatory method, meaning no NBP measurement is possible.

Why aren't the NBP and invasive arterial line mean values always the same?

Differences between the Mean Arterial Pressure (MAP) for invasive and noninvasive measurements are common and should not be reason for concern. The MAP represents the average pressure exerted during the cardiac cycle. From an arterial line, it is calculated by measuring the area under the curve[5] divided by the time interval and is done on a beat-by-beat basis. For the NBP using the oscillometric method, the MAP is measured at the maximum oscillation amplitude over a period of 30-50 seconds, i.e. many heart beats.



For best correlation, average several invasive blood pressure (IBP) MAP measurements over a brief time period, then compare this value to the NBP MAP.

During my training, I was taught to calculate the MAP using the equation MAP = (SYS + 2DIA)/3. Why doesn't the MAP from the monitor NBP follow this formula?
Manual measurement of blood pressure using a cuff, sphygmomanometer and stethoscope use the auscultatory measurement method. Both the systolic and diastolic pressures are measured and the MAP can be calculated using the above formula. The monitor uses the oscillometric measurement method, where the MAP is measured and the systolic and diastolic pressures are calculated. As two-thirds of a typical cardiac cycle is spent in diastole when the mean heart rate is 60 bpm, it is a common clinical practice to approximate the mean pressure as established by the MAP formula referred to above. However, as the proportion of the cardiac cycle is spent in diastole changes with a varying heart rate, the MAP formula becomes less precise in estimating the invasive mean artierial pressure by noninvasive methods. For this reason, the formula is most accurate in patients with heart rates close to 60 bpm, especially with a sinus rhythm.

Because the MAP is measured in the oscillometric method, variable heart rate does not affect the value unless it is extreme or can be attributed to arrhythmias.

Why do I sometimes get a "mean only" measurement?
A mean only measurement indicates that the system did not have sufficient information to determine the systolic and diastolic values. This will typically occur during intervals of severe patient motion or if the inflation limit is set too low for the patient. To ensure optimum performance, verify that the inflation limit is set appropriately for the intended application prior to each use and use best clinical practices to manage patient movement.

I work in Recovery (PACU) and it is sometimes difficult to get a measurement. The patient will be waking up from anesthesia and will be moving or shivering.
Patient motion, including excessive movement, tremors, convulsions, and seizures, can generate significant artifact that interferes with the signal necessary for the monitor to obtain a valid measurement. This will be accompanied by an ARTIFACT message on the monitor display. Use best clinical practices to manage patient movement.

Sometimes the patient is not moving at all and I can't get a measurement.
The effectiveness of the oscillometric method, like all noninvasive measurement techniques, may be limited on some patients experiencing various arrhythmias, extremely high or low heart rates, or low peripheral perfusion. As all of these conditions can constitute critical conditions that may need immediate intervention, it is imperative that you clinically assess the patient before troubleshooting the monitor.

The system will also fail to obtain a measurement should the inflation limit be set below the patient's systolic pressure, or if the cuff is incorrectly applied. Refer to the directions for use provided with the cuff and follow the troubleshooting guide for additional information.

When do I need to change the inflation limits?
The monitor has both default and user-configurable inflation limits. The default limits are set based on the patient category selected during monitor set up and represent normal pressure ranges for that category. The inflation limit may be adjusted for patients falling outside the normal range – as may be the case on extremely hypertensive patients, or when lower inflation pressures are desired.

I've been buying my cuffs from another supplier. Will they work with our Dräger Medical monitor?
Dräger Medical monitors go through vigorous testing, both in a laboratory as well as in the real clinical setting. They are tested with the accessories that Dräger Medical supplies. The accuracy of the NBP is dependent upon the correct cuff size, which includes both the physical dimension of the cuff, as well as the internal inflatable bladder. As these can vary greatly among manufacturers, we only recommend the use of Dräger Medical approved cuffs.

Can I use the child cuff on all children?
The child cuff is designed to fit most children. However, like all cuffs, the patient designation is a general guide only and proper application depends on the circumference of the limb to which it will be applied. When affixing the cuff, ensure that the index line falls within the range markings on the cuff. For more information regarding cuff selection, refer to the directions for use provided with the cuff.

Troubleshooting

Monitor Message	Condition	Action
NBP no pulsation	Too few cardiac pulsations or insufficient pulse amplitude are detected	As this may be a critical condition, check whether the patient has a palpable pulse. Check cuff size and proper placement of cuff
NBP measurement timeout	Measurement time has exceeded 3 minutes	If appropriate, increase inflation limit
NBP artifact	Artifact is detected during a measurement	Move cuff to a limb with less movement
NBP open line	No significant increase in cuff pressure during the inflation cycle	Check hose connection
NBP blocked line	Blocked output condition detected	Check hose connection
NBP cuff leak	The drop in cuff pressure following the end of the inflation cycle is too great	Check cuff and hose for leaks
NBP overpressure	The cuff pressure has exceeded the overpressure threshold	Check hose connection
NBP mean only	The blood pressure profile measured could only yield a valid mean value	Check size and proper placement of cuff

Troubleshooting

Monitor Message	Condition	Action
NBP out of range	NBP values are above or below specified measurement range	Check patient condition (there are hypertensive crises where the systolic pressure is beyond the NBP range) If appropriate, increase inflation limit
NBP low inflation limit	NBP systolic value higher than inflation limit	If appropriate, increase inflation limit

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