Blood Pressure Measurement

Blood pressure is the lateral force exerted by blood on the arterial walls. It depends on the force of ventricular contractions, arterial wall elasticity, peripheral vascular resistance, and blood volume and viscosity. Systolic, or maximum, pressure occurs during left ventricular contraction and reflects the integrity of the heart, arteries, and arterioles. Diastolic, or minimum, pressure occurs during left ventricular relaxation and directly indicates blood vessel resistance.

Pulse pressure, the difference between systolic and diastolic pressures, varies inversely with arterial elasticity.

Rigid vessels, incapable of distention and recoil, produce high systolic pressure and low diastolic pressure. Systolic pressure normally exceeds diastolic pressure by about 40 mm Hg. Narrowed pulse pressure—a difference of less than 30 mm Hg—occurs when systolic pressure falls and diastolic pressure rises. These changes reflect reduced stroke volume, increased peripheral resistance, or both. Widened pulse pressure—a difference of more than 50 mm Hg between systolic and diastolic pressures—occurs when systolic pressure rises and diastolic pressure remains constant or when systolic pressure rises and diastolic pressure falls. These changes reflect increased stroke volume, decreased peripheral resistance, or both.

Frequent blood pressure measurement is critical after serious injury, surgery, or anesthesia and during any illness or condition that threatens cardiovascular stability. Measurement can occur manually or via an automated blood pressure device.

Frequent blood pressure measurement may also be necessary for unstable patients and for those receiving blood transfusions or oral or IV medications that stabilize blood pressure. Guidelines recommend regular measurement for patients with a history of hypertension or hypotension and annual screening for all adults.

Blood pressure measurement should occur in the upper arm using the auscultatory or oscillatory method. When obtaining a baseline measurement, nurses should measure blood pressure in both arms. If significant differences in blood pressure exist from one arm to the other, documentation should reflect which arm has the higher pressure and that arm should be used for measurements. For subsequent blood pressure monitoring, measurement? should occur in the same arm using the same device to ensure accurate measurement.

Equipment

- Aneroid sphygmomanometer with an appropriately sized cuff
- Disinfectant pads
- Facility-approved disinfectant
- Gloves
- Stethoscope
- Optional: automated vital signs monitor, other personal protective equipment

A sphygmomanometer consists of an inflatable compression cuff linked to a manual air pump and an aneroid gauge. Use a recently calibrated aneroid gauge. Wall-mounted devices require calibration at least every 6 months, whereas handheld devices require calibration every 2 to 4 weeks. To obtain an accurate reading, rest the gauge in any position, but view it directly from the front.

Cuffs come in sizes that range from newborn to extra-large adult. Disposable cuffs and thigh cuffs are available. Use an appropriately sized cuff, and follow the manufacturer's instructions for proper fit and placement.

An automated blood pressure device is a noninvasive device that measures pulse rate, systolic and diastolic pressures, and mean arterial pressure at preset intervals.

USING AN AUTOMATED BLOOD PRESSURE DEVICE

An automated blood pressure device enables you to track a patient's blood pressure continually without having to reapply a blood pressure cuff each time. In addition, it eliminates the need for an invasive arterial line to gather similar data.

Some automated blood pressure devices are lightweight, are battery operated, and can be attached to an IV pole for continuous monitoring, even during patient transfers. Make sure that you know the battery capacity of the device you're using, and plug in the machine whenever possible *to keep it charged.* Calibrate the device regularly *to ensure accurate readings.*

An oscillatory device isn't as accurate as auscultatory blood pressure measurement because it can overestimate or underestimate blood pressure. Before using any automated blood pressure device, check its accuracy. An oscillatory device should meet the Association for the Advancement of Medical Instrumentation standards when compared with the auscultatory method.

Determine the patient's pulse rate and blood pressure manually using the same arm you'll use for the device cuff. Compare your results when you get initial readings from the device. If the results differ, call your supply department or the manufacturer's representative.

Check the manufacturer's guidelines *because most automated monitoring devices are intended for serial monitoring only and may be inaccurate for a one-time measurement.*

Preparing the device

- Explain the procedure to the patient and family (if appropriate) according to their individual communication and learning needs *to increase their understanding, allay their fears, and enhance cooperation.* Describe the alarm system *so that the patient won't be frightened if it's triggered.*
- Make sure that the power switch is off. Then plug the device into a properly grounded wall outlet.
- Secure the dual air hose to the front of the device.
- Connect the pressure cuff's tubing into the other ends of the dual air hose, and tighten the connections *to prevent air leaks.* Keep the air hose away from the patient *to avoid accidental dislodgement.*
- Squeeze all air from the cuff and then wrap it around the patient's upper arm about ¾? to

1? (2 to 2.5 cm) above the antecubital fossa. Never apply the cuff to a limb that has a peripherally inserted central catheter or midline catheter in place. Position the cuff's ARTERY arrow over the palpated brachial artery. Then secure the cuff for a snug fit.

Selecting parameters

- When you turn on the device, it will default to a manual mode. (In this mode, you can obtain vital signs yourself before switching to the automatic mode.) Press the AUTO/MANUAL button to select the automatic mode. The monitor will give you baseline data for the pulse rate, systolic and diastolic pressures, and mean arterial pressure.
- Compare your previous manual results with these baseline data. If they match, you're ready to set the alarm parameters. Press the SELECT button to blank out all displays except systolic pressure.
- Use the HIGH and LOW limit buttons to set the specific parameters for systolic pressure. (These limits range from a high of 240 mm Hg to a low of 0 mm Hg.) Do the same for mean arterial pressure, pulse rate, and diastolic pressure. After you've set all the parameters, press the SELECT button again to display all current data. Note that even if you forget to do this last step, the device will automatically display current data 10 seconds after you set the last parameters.
- Make sure that the alarm limits are set appropriately for the patient's current condition and that the alarms are turned on, functioning properly, and audible to staff.

Collecting data

- You must also program the device to the desired frequency according to the manufacturer's instructions. Press the SET button until you reach the desired time interval in minutes. To minimize complications, use the maximum (least frequent) cycle time for the shortest time period.
- You can obtain a set of vital signs at any time by pressing the START button.
- Pressing the CANCEL button will stop the interval and deflate the cuff.
- You can retrieve stored data by pressing the PRIOR DATA button. The device will display the last data obtained along with the time elapsed since then. Scrolling backward, you can retrieve data from the previous 99 minutes.
- Ensure frequent documentation of the patient's vital signs in a vital signs assessment record.

Preparation of Equipment

Inspect all equipment and supplies. If a product is expired, is defective, or has compromised integrity, remove it from patient use, label it as expired or defective, and report the expiration or defect as directed by your facility.

Choose an appropriately sized cuff carefully for the patient; the cuff bladder length should be 75% to 100% of the measured upper arm circumference, and the bladder width should be 37% to 50% of the arm circumference (a length-to-width ratio of 2:1). *A cuff that is too small may cause a false-high pressure reading; a cuff that is too large may cause a false-low reading.*

FACTORS IMPACTING BLOOD PRESSURE MEASUREMENT

Accurate blood pressure measurement relies on standardizing techniques and proper equipment.2 When measuring blood pressure, keep the following factors in mind:

- Read the dial at eye-level.
- Before measurement, provide the patient with a 3- to 5-minute rest period without talking or moving.
- Place the cuff on bare skin.
- Avoid rolling shirtsleeves to prevent a tourniquet effect.
- Rapid deflation can cause inaccuracies. (Deflation shouldn't exceed 2 to 3 mm Hg/second.)
- Ensure that the patient avoids caffeine intake, smoking, and exercise for at least 30 minutes before measurement.
- The patient's bladder should be empty.
- The patient shouldn't talk during measurement.
- The environment should be quiet.
- The patient's legs should be uncrossed.

To use an automated vital signs monitor, collect the monitor, dual air hose, and pressure cuff. Then make sure that the monitor unit is positioned firmly near the patient's bed.

Implementation

- Gather and prepare the necessary equipment and supplies.
- Perform hand hygiene.
- Confirm the patient's identity using at least two patient identifiers.
- Have the patient rest for 3 to 5 minutes before measuring blood pressure.
- Make sure that the patient hasn't smoked or used other tobacco products, exercised, or had caffeine for at least 30 minutes.
- Provide privacy.
- Explain the procedure to the patient and family (if appropriate) according to their individual communication and learning needs *to increase their understanding, allay their fears, and enhance cooperation.*
- Position the patient supine or with the head of bed at a comfortable level, or have the patient sit erect during blood pressure measurement in the upper arms. If the patient is sitting erect, ensure support of the patient's back and arms and make sure that the legs are uncrossed and both feet are on the floor *because crossing the legs can increase blood pressure.*Extend the patient's arm at heart level (the phlebostatic axis—fourth intercostal space, halfway between the anterior and posterior diameter of the chest) and provide support.

✹ ***Clinical alert:*** Note that measuring blood pressure with a patient seated on an examination table or the side of a bed with the back unsupported may cause false elevations in blood pressure.

- Make sure that the patient is relaxed and comfortable when you measure blood pressure *so that the blood pressure stays at its normal level.*
- Remain quiet during blood pressure measurement. Instruct the patient to do the same *because systolic and diastolic blood pressures increase with talking.*
- Wrap the deflated cuff snugly around the patient's upper arm so that the end of the cuff is ¾" to 1¼" (2 to 3 cm) above the antecubital fossa *to enable placement of your*

stethoscope. Align the cuff to make sure that the ARTERY mark on the cuff is positioned over the artery (as shown below). The cuff should fit snugly but should still allow for two fingers to slide beneath it.

Clinical alert: Don't measure blood pressure in an extremity with deep vein thrombosis, grafts, or ischemic changes. Don't apply a blood pressure cuff over a peripherally inserted central catheter or midline catheter; you may apply the cuff distal to the insertion site. Avoid blood pressure measurement in extremities with a peripheral IV catheter while fluid is infusing and in patients who have an incision or have undergone trauma. Don't measure blood pressure in an extremity affected by lymphedema after mastectomy or lumpectomy *because doing so can further compromise lymphatic circulation and worsen edema.* Likewise, don't take blood pressure on the same arm as an arteriovenous fistula or a hemodialysis shunt *because doing so might compromise blood flow through the vascular device.*

- If necessary, connect the appropriate tube to the rubber bulb of the air pump and the other tube to the gauge.
- Determine how high to inflate the blood pressure cuff by estimating systolic blood pressure using palpation. As you feel the radial artery with the fingers of one hand, inflate the cuff until the radial pulse disappears. Read this pressure on the gauge and add 30 mm Hg to it. Use this sum as the target inflation *to prevent discomfort from overinflation.* Deflate the cuff.
- Locate the brachial artery by palpation. Center the diaphragm or bell of the stethoscope over the part of the artery where you detect the strongest beat and hold it in place with one hand. Place the stethoscope earpieces in your ears.
- Close the valve of the sphygmomanometer. Using the thumb and index finger of your other hand, turn the thumbscrew on the rubber bulb of the air pump clockwise to close the valve.
- Pump up the cuff to the predetermined level.
- Open the valve of the air pump carefully and then slowly deflate the cuff—between 2 and 3 mm Hg/second.2 While releasing air, watch the mercury column or aneroid gauge and auscultate for the sound over the artery.
- When you hear the first beat or tapping sound, note the pressure on the column or gauge, which is the systolic pressure. (The beat or tapping sound is the first of five Korotkoff sounds. The second sound resembles a murmur or swish; the third sound, crisp tapping; the fourth sound, a soft, muffled tone; and the fifth sound is when the sound stops.)
- Continue to release air gradually while auscultating for the sound over the artery.
- Note the pressure when the sound stops (the fifth Korotkoff sound); this is the diastolic pressure.
- After you hear the last Korotkoff sound, deflate the cuff slowly for at least another 10 mm Hg *to ensure that no further sounds are audible.*
- Deflate the cuff rapidly and record the pressure.
- Remove the cuff.
- Check the patient's skin integrity under the blood pressure cuff.
- Perform hand hygiene.
- Clean and disinfect your stethoscope with a disinfectant pad.

- Perform hand hygiene.
- Put on gloves and, as needed, other personal protective equipment *to comply with standard precautions.*
- Clean and disinfect other reusable equipment according to the manufacturer's instructions *to prevent the spread of infection.*
- Discard used supplies in appropriate receptacles.
- Remove and discard your gloves, if worn, and other personal protective equipment.
- Perform hand hygiene.
- Document the procedure.

Special Considerations

- If you can't use the upper arm for blood pressure measurement or the maximal cuff size won't fit the patient's upper arm properly, measure blood pressure using the forearm.
- Note that blood pressure measurements in the forearm and upper arm aren't interchangeable.3 Studies have shown that upper arm systolic and diastolic blood pressure measurements with an appropriate cuff were significantly lower than forearm blood pressure measurements with a standard cuff.3031323334 When measuring blood pressure in the forearm, choose a cuff of adequate size. (Guidelines recommend a cuff with a bladder large enough to go around 80% of the forearm.)
- Position the cuff midway between the elbow and wrist, and position the forearm at the level of the patient's heart. Auscultate Korotkoff sounds over the radial artery.
- If you can't use the patient's upper arms or forearms, measure blood pressure using the thigh or calf.3 Keep in mind that blood pressure measurements in the thigh or calf aren't interchangeable with upper arm measurements. Use the same attention to selecting a proper cuff size as you would for blood pressure measurement at other sites. For calf blood pressure measurement, position the patient supine, and place the cuff about 1″ (2.5 cm) above the malleoli.
- Auscultate Korotkoff sounds over the dorsalis pedis or posterior tibial artery. For thigh measurement, position the patient prone and position the cuff over the lower third of the thigh so that the lower edge of the cuff is about ¾″ to 1¼″ (2 to 3 cm) above the popliteal fossa. Auscultate Korotkoff sounds over the popliteal artery. If the patient can't tolerate prone positioning, place the patient supine with the knee slightly bent.
- If you can't auscultate blood pressure, you may estimate systolic pressure. To do this, first palpate the brachial or radial pulse. Then inflate the cuff until you no longer detect the pulse.
- Deflate the cuff slowly and, when you detect the pulse again, record the pressure as the palpated systolic pressure.
- Be aware that patients with aortic dissection, congenital heart disease, coarctation of the aorta, peripheral vascular disease, and unilateral neurologic and musculoskeletal abnormalities may demonstrate a difference in blood pressure between the two arms. If you detect such a difference, use the arm with the higher pressure.
- If the patient is crying or anxious, delay blood pressure measurement (if possible) until the patient becomes calm *to avoid falsely elevated readings.*
- You'll occasionally have to measure blood pressure in both arms or with the patient in two different positions (such as lying and standing or sitting and standing). In such cases, observe and record any significant difference between the two readings, and record the blood pressure for each extremity and position you used.
- The Joint Commission issued a sentinel event alert concerning medical device alarm

safety *because alarm-related events have been associated with permanent loss of function or death.* Among the major contributing factors were improper alarm settings, alarm settings turned off inappropriately, and alarm signals that were inaudible to staff. Make sure that alarm limits are set appropriately and that alarms are turned on, functioning properly, and audible to staff. Follow facility guidelines for preventing alarm fatigue.

Complications

Complications associated with blood pressure measurement may include:

- bruising
- prolonged use of automated electronic blood pressure devices and frequent blood pressure measurement
    - compartment syndrome
    - ecchymosis
    - limb edema
    - pain
    - peripheral neuropathy
    - petechiae
    - phlebitis
    - thrombophlebitis
    - venous stasis
- compromised blood flow through the vascular device (due to blood pressure measurement on the same arm as an arteriovenous fistula or hemodialysis shunt)
- inadequate and unnecessary treatment (due to inaccurate readings as a result of improper technique)
- skin irritation.

Documentation

Documentation associated with blood pressure measurement includes:

- blood pressure results, as systolic pressure over diastolic pressure to the nearest even number (such as 120/78 mm Hg)
    - name of the practitioner notified about blood pressure results
    - date and time of notification
    - prescribed interventions
    - response to those interventions
- auscultatory gap (if present)
- blood pressure on a graph using dots or checkmarks (if required)
- extremity used
- position
- time of the patient's most recent blood pressure medications (if applicable)
- teaching provided to the patient and family (if applicable)
    - understanding of that teaching
    - follow-up teaching needed.