Blood-Pressure Measurement

Article *in* New England Journal of Medicine · February 2009

DOI: 10.1056/NEJMvcm0800157 · Source: PubMed

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Published in final edited form as:
N Engl J Med. 2009 January 29; 360(5): e6. doi:10.1056/NEJMvcm0800157.

Videos in Clinical Medicine Blood Pressure Measurement

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Supplementary Text

Indications

Blood pressure measurement is indicated in any situation that requires assessment of cardiovascular health, including screening for hypertension and monitoring effectiveness of treatment in patients with hypertension. In the routine outpatient setting blood pressure measurement is obtained indirectly, thus it is important that proper techniques be used so as to produce consistent and reliable measurements.

Contraindications

Measuring blood pressure at the brachial artery is a relatively benign process. However, there are some circumstances in which taking readings from an arm may not be appropriate. Such situations include the presence of an arterial-venous shunt, recent axillary node dissection, or any deformity or surgical history that interferes with proper access to the upper arm. If these relative contraindications are present, blood, pressure should be assessed in the opposite arm. There may also be pre-existing conditions that can interfere with accuracy or interpretation of readings such as aortic coarctation, arterial-venous malformation, occlusive arterial disease, or the presence of an antecubital bruit.

Equipment

Regular inspection and calibration of equipment is important to ensure that it is in proper working order. Biannual calibrations are recommended to assure accuracy. [1, 2]

The stethoscope tubing should be of appropriate length to permit the practitioner to auscultate Korotkoff sounds while viewing the manometer at eye level. Using the bell side of the stethoscope chestpiece facilitates auscultation of the low frequency Korotkoff sounds. The sphygmomanometer consists of a blood pressure cuff containing a distensible bladder, a rubber bulb with an adjustable valve for inflation, the connecting tubing and a manometer to display the pressure level (Figure 1).

Many institutions have removed mercury manometers from clinical settings and replaced them with aneroid manometers. The steps required for accurate blood pressure measurement are identical whether using aneroid or mercury manometers.

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Preparation

The examination room should be quiet, with a comfortable ambient temperature. Ideally, blood pressure should not be measured if the patient has engaged in recent physical activity, used tobacco, ingested caffeine, or eaten within 30 minutes.[3]

Patient Positioning

Correct patient positioning is essential for accurate measurement. The patient's back and legs should be supported, with legs uncrossed and feet resting on a firm surface. The arm in which blood pressure will be measured should be bare to the shoulder and the garment sleeve, if raised, should be sufficiently loose so that it does not interfere with blood flow or proper cuff positioning. The arm should be supported and level with the heart. The manometer should be positioned at eye-level to the health care practitioner.

Arm Measurement

A common error in measuring blood pressure is the use of an improperly fitted cuff. Undersized cuffs will result in overestimation of blood pressure. Selection of an appropriately sized cuff requires assessment of *arm circumference* at the midpoint of the upper arm, to assure that a properly fitted cuff is used. One half the distance between the acromion and olecranon process determines the arm *mid-point* (Figure 2). The arm circumference is then measured at the arm mid-point.

Cuff Sizing

Cuffs are typically manufactured marked with sizing indicators (e.g. adult or large adult) intended to facilitate proper fitting. The *index line* runs perpendicular to the length of the cuff, while the *range line* runs parallel to the length of the cuff. Once wrapped around the arm, the index line should fall within the range line limits, and the mid-point of the bladder should sit over the brachial artery.

In addition to index and range lines, cuffs will often indicate size or size ranges. The sizes marked on the cuff should correspond to the appropriate arm circumferences (Table 1). While these may be helpful guides, it is most important to use a cuff that is the appropriate size for the arm, based on arm measurement and inspection of the match between the index and range lines once the cuff is placed on the patient. A cuff that is too small may contribute to a falsely elevated blood pressure measurement.

Cuff Placement

The cuff should be placed on a bare arm approximately 2 cm superior to the elbow crease with the midline of the bladder (usually indicated by the manufacturer) directly over the brachial artery (Figure 3). It should fit snuggly, but still allow for two finger widths to slide under the cuff.

Pulse Obliteration Pressure

Inflating the cuff to an arbitrary level runs the risk of excessive over-inflation and undue patient discomfort, or under-estimation of systolic blood pressure. To avoid underestimating blood pressure due to an ascultatory gap, one should determine the *pulse obliteration pressure*, which can then be used to estimate an appropriate initial cuff inflation pressure. An *auscultatory gap* is present when there is intermittent disappearance of the initial Korotkoff sounds *after their first appearance*. It is more likely to be present in older hypertensive individuals and can lead to underestimation of systolic blood pressure.[4] Estimating systolic blood pressure by first measuring *pulse obliteration pressure* helps avoid an incorrect measurement of systolic blood pressure in this setting.

To determine the pulse obliteration pressure, palpate the radial pulse while rapidly inflating the cuff to approximately 80 mmHg. Then slow the inflation rate to approximately 10 mmHg every 2–3 seconds taking note of the reading at which the pulse disappears. After the pulse has disappeared, deflate the cuff at a rate of 2 mmHg per second, noting when the pulse reappears, which confirms the obliteration pressure.

Blood Pressure Measurement

Place the bell of the stethoscope over the brachial artery with sufficient pressure to provide good sound transmission without over-compressing the artery. The stethoscope should not be in contact with clothing or with the cuff, to avoid extraneous noise during cuff deflation.

Once the pulse obliteration pressure is determined, initiate the auscultatory blood pressure measurement by rapidly inflating the cuff to a level 20–30 mmHg above the pulse obliteration pressure. Then deflate the cuff at a rate of 2 mmHg per second while listening for the Korotkoff sounds.

Korotkoff Sounds

As the cuff is deflated, turbulent blood flow through the brachial artery generates a series of sounds. Classically, these have been described according to 5 phases:

- Phase 1 Sound: Clear, repetitive, tapping, coinciding with reappearance of a palpable pulse. The initial appearance of Phase 1 sounds is equal to the *systolic blood pressure*
- Phase 2 Sound: Audible murmurs in the tapping sounds are heard
- Phase 3 and 4: Muted changes in the tapping sounds occur as the pressure measurement approaches the diastolic pressure (usually within 10 mmHg of true diastolic pressure)
- Phase 5 Sound: This phase is not really a “sound,” rather it indicates the disappearance of sounds and equates to the *diastolic blood pressure*

To ensure that diastole has been reached, continue to deflate the cuff pressure for an additional 10 mmHg beyond the fifth Korotkoff sound.

Take a minimum of 2 blood pressure measurements, interspaced by at least one minute.[1] Record the average of the measurements as the blood pressure.

Blood Pressure Classification

Normal adult blood pressure is defined as a systolic pressure less than 120 mmHg and a diastolic less than 80 mmHg. Higher blood pressures are labeled as denoting pre-hypertension and hypertension, which is also divided into stages (Table 2).[1]

Observer Error

A common error in blood pressure measurement is the introduction of *observer bias*, which occurs in two forms: (1) when practitioners show terminal digit preference or (2) rounding of the terminal digits, as may commonly occur when recorded blood pressure levels are rounded to a “0” or “5.”[1] Manometer scales are generally scored in 2 mmHg increments, so a terminal digit of 5 cannot be read and the terminal digit “0” should only occur 20% of the time. Using an appropriate deflation rate and carefully recording the appearance and disappearance of Korotkoff sounds generally facilitates precise measurement.

A *parallax error* may occur when mercury manometers are used if the observer is not at eye-level with the mercury column. Such misalignment between the eye and the mercury meniscus may cause the meniscus to be read at a level that is either higher or lower than the actual position.

Special Circumstances

Certain clinical conditions may complicate blood pressure measurement or its interpretation. Such instances include:

- Arrhythmias and dysrhythmias: Irregularity in the timing of Korotkoff sounds (e.g. atrial fibrillation) can decrease the accuracy of a measurement. Accuracy can be improved by decreasing the deflation rate and by taking an average of several measurements.
- Persistent Systole: Atherosclerotic vascular disease can result in the persistence of audible Korotkoff sounds (prolonged Korotfoff phase 4 or absence of phase 5) despite deflation to 0 mmHg. This is termed *persistent systole* and may occur in elderly patients and during pregnancy. In this situation, diastole should be estimated by noting the appearance of the fourth Korotkoff sound.
- Anthropometric Mismatch: Occasionally, a patient with an exceptionally large arm circumference requires a cuff size that cannot be adequately positioned between the antecubital fossa and upper arm. This situation can lead to patient discomfort and inadequate compression of the brachial artery. If an appropriate cuff cannot be fitted above the brachial artery, then it may be better to place a cuff on the forearm with auscultation of Korotkoff sounds at the radial artery. Care should be taken to ensure that the forearm is supported level with the heart to avoid a false elevation in pressure from increased hydrostatic forces if the forearm is below heart level.
- Diurnal Variation/Timing of Measurement: Normal blood pressure fluctuates over the 24-hour period. In some situations it is prudent to obtain measurements at different times during the day, particularly when diagnosing or monitoring hypertension. In this same regard it is also important to consider the timing and type of anti-hypertensive medications used when interpreting blood pressure measurements in hypertensive patients.

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Figure 1. Equipment used in blood pressure measurement

The essential equipment for blood pressure measurement includes a stethoscope and a sphygmomanometer. The stethoscope should have tubing of sufficient length to allow auscultation of Korotkoff sounds while viewing the manometer at eye level. The sphygmomanometer includes a blood pressure cuff with a distensible bladder, tubing connected to the cuff and a rubber bulb with an adjustable valve for coordinating inflation and deflation, and a manometer to display the pressure level in the cuff.

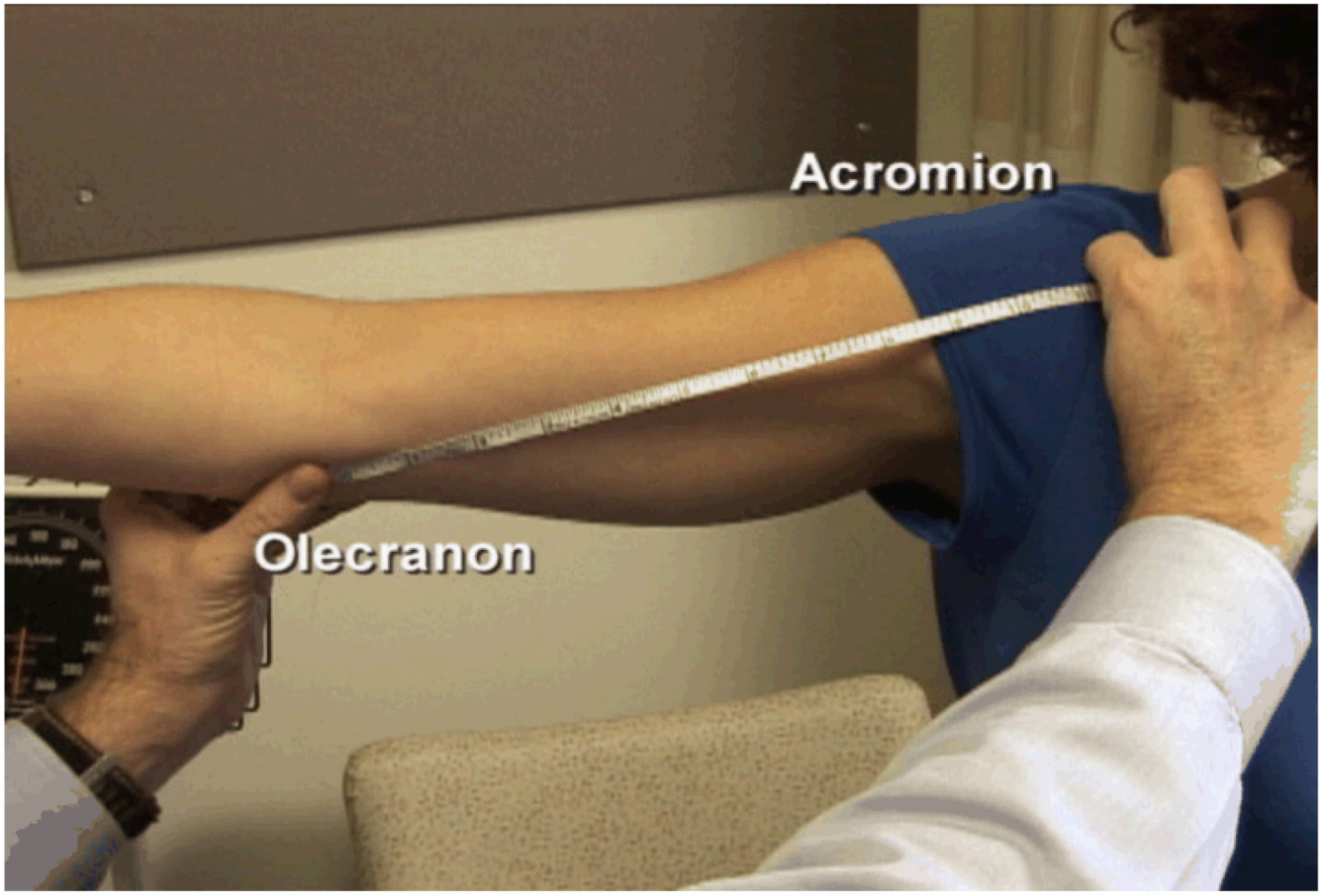

Figure 2. Arm measurements for assessing cuff size

Two arm measurements are used to determine the appropriate cuff size to use: the midpoint of the arm and the arm circumference at the mid-point. To determine the mid-point, the distance between the acromion and olecranon process are determined, then arm circumference is measured at the arm mid-point.

Figure 3. Proper positioning of the blood pressure cuff

A cuff of appropriate size is wrapped around the bare upper arm. It should be well-fitting and snug, but still allow two fingers to fit under the cuff. The lower end of the cuff should be approximately 2 cm above the elbow crease. The midline of the bladder should be placed over the brachial artery.

Table 1

Blood Pressure Cuff Sizing

Arm Circumference (cm)	Bladder Dimensions (cm)	Cuff Size
22 to 26	12 × 22	Small Adult
27 to 34	16 × 30	Adult
35 to 44	16 × 36	Large Adult
45 to 52	16 × 42	Adult Thigh

Table 2

Blood Pressure Classification

Classification	Systolic (mmHg)	Diastolic (mmHg)
Normal	<120	and <80
Prehypertension	120–139	or 80–89
Stage I hypertension	140–159	or 90–99
Stage II hypertension	≥160	or ≥100