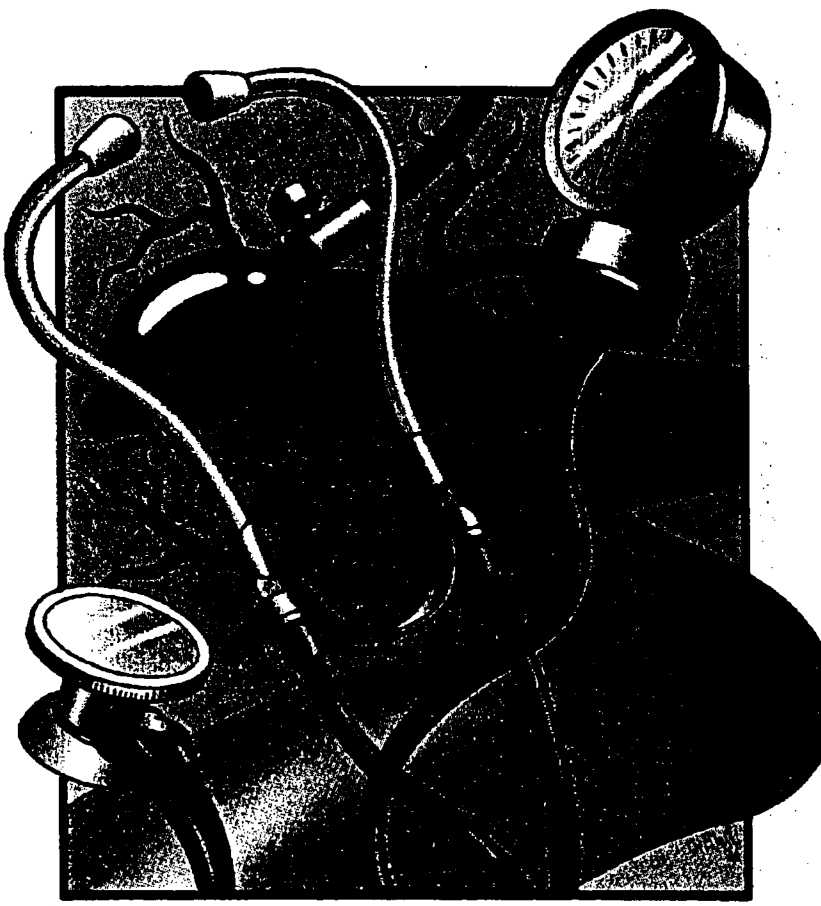
American Heart Association℠

Fighting Heart Disease and Stroke

Human Blood Pressure Determination by Sphygmomanometry

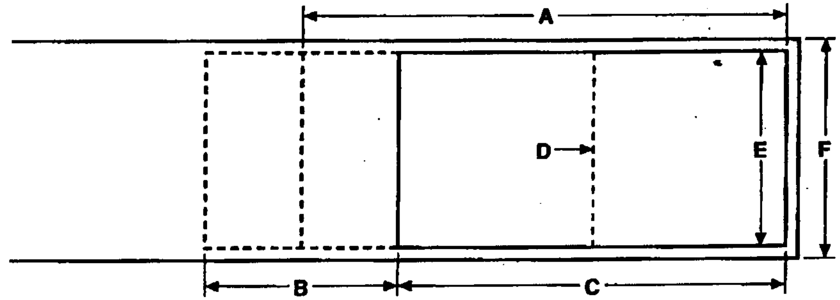


the mercury during deflation reflects clogging of the air vent or dirt or air bubbles in the column. The column should be kept vertical except on the specially designed floor models, which have a slanted scale. See Appendix C for safety precautions for the use of mercury.

The aneroid manometer is also widely used and can provide accurate measurements if properly calibrated.[16] However, because of its construction, it is prone to mechanical alterations that can affect its accuracy. The aneroid manometer consists of a metal bellows, which expands as the pressure in the cuff increases, and a mechanical amplifier that transmits this expansion through a lever to the indicator needle, which rotates around a circular, calibrated scale. The needle should rest at the zero point before the cuff is inflated and return to that point after the cycle of inflation and deflation. Aneroid manometers require maintenance every 6 months and should be handled gently to avoid decalibration. The accuracy of the calibration should be checked regularly (Fig 1). Recalibration is required when the readings differ from the standard mercury manometer by more than 4 mm Hg. When decalibrated, aneroid manometers tend to underread the pressure, especially at higher levels, but may be inconsistent in their variation from the mercury standard at any blood pressure level.

Inflation system. The inflation system consists of an expandable, rectangular rubber bladder encased in a nondistensible cuff, an inflation bulb, and connecting tubing. The cuffs used for oscillometric determination of the blood pressure do not have a removable bladder separate from the cuff. The cuff is applied by wrapping it completely around the limb so that the noninflatable portion overlaps that containing the bladder, and is secured with a self-adhesive material such as Velcro. The bladder is connected by rubber tubing to the manometer, which reflects the pressure inside the bladder. The tubing must be free of leaks and long enough that the subject can be comfortably positioned next to the manometer without the tube's becoming kinked or compressed, which could interfere with smooth inflation or deflation. The bladder is also connected by a shorter tube to a valved rubber bulb, which is used to inflate and deflate the bladder at a rate controlled by the release valve.

Considerable thought has been given to the size and dimensions of the occluding bladder and its encasing cuff.[17-19] The variables considered are the length and width of the bladder and the ratio of one to the other, the relation of the width of the bladder to the length



A: Ideal arm circumference; B: Range of acceptable arm circumferences; C: Bladder length; D: Midline of bladder; E: Bladder width; F: Cuff width

Fig 2. Dimensions of bladder and cuff in relation to arm circumference.

of the upper arm, and the relation of both the width and the length of the bladder to the circumference of the arm. For any arm circumference, as the bladder size (length and width) is increased in a stepwise manner the blood pressure reading is progressively lower, until a plateau is reached at which no further increase in cuff size results in further reduction of the blood pressure measurement.[19] This plateau occurs approximately when the width of the bladder is 40% of the circumference of the upper arm at the midpoint and the length of the bladder is 80% of the circumference of the arm. The use of a bladder that is too small (too narrow or too short) for the circumference of the limb results in overestimation of the blood pressure.[19] The error of underestimation of the pressure, which results from the use of a bladder that is too large, is less than the error of overestimation with a bladder that is too small. To date there is no published systematic study that relates the measurements made with stepwise increments in cuff dimensions (length and width), in arms of varying circumferences and lengths, to simultaneous intra-arterial measurements. Hence, the committee's consensus recommendation is based on the available literature. It is recommended that the width of the bladder be 40% of the arm circumference, and the length of the bladder be long enough to encircle at least 80% of the arm in adults. In children the occluding bladder should be long enough to encircle the arm completely (100%). Overlapping of the ends of the bladder in children does not appear to introduce an error in measurement.

The cuffs generally available have been classified by the width of the bladder rather than by the length and are labeled "newborn," "infant," "child," "small adult," "adult," "large adult," and "thigh," but different manufacturers have produced cuffs of varying dimensions (both length and width) under these names because no universal standards have been established. A large number of cuffs with varying sizes of bladders are commercially available, but not all of these are of the recommended dimensions. Ideally, every cuff should be labeled with the dimensions of the enclosed bladder; a line should mark the center of the bladder, and two lines should indicate the range of arm circumferences for which the bladder is suitable, ie, encircling 80% to 100% of the circumference (Fig 2). Unlabeled cuffs should be so marked by the user. For cuffs with longer bladders, a length:width ratio of more than 2:1, the corresponding appropriate arm circumference is greater; however, the ratio of bladder width to arm circumference should be as close as possible to 0.40. (See Appendix D for a list of some acceptable bladder sizes and the arm circumferences for which they are suitable. A number of cuffs with intermediate bladder dimensions are available, but to simplify the selection only some of them are listed here.) Although it is not feasible for every examiner to have all cuff sizes available, except under research conditions, it is strongly recommended that the practitioner have several sizes available to meet the needs of the population served. However, in individuals with very wide but short arms, the appropriately sized bladder may be difficult to apply. Likewise, in individuals with very large or muscular arms, even the largest cuff may be inadequate. The British Hypertension Society has recommended the use of one large cuff (12.5 × 35 cm) for all adults with an arm circumference up to 42 cm, to avoid the need for multiple cuff sizes.[18,20] The use of such a cuff could lead to systematic underestimation or overestimation of the pressure when the ratio of bladder width to arm circumference is different from 0.40.

Automated devices. Many automated devices are available to measure blood pressure by both auscultatory and oscillometric techniques. The oscillometric method is based on detecting the oscillations on the lateral walls of the occluded artery as the cuff is deflated. The oscillations begin at approximately the level of systolic pressure and reach their greatest amplitude at the level of mean arterial pressure. Diastolic pressure is a derived value. Systolic

blood pressure measurement by these devices is accurate, but diastolic pressure, which is derived from the systolic and mean pressures, may not be. The cuffs used for oscillometric measurement are constructed without a removable bladder. Although absolute measurements made with these cuffs may vary slightly from those made with standard cuffs, overall trends in blood pressure level can be readily tracked. However, serious doubt has been raised about the accuracy of devices applied to the finger or wrist because their extreme sensitivity to position results in wide fluctuations in blood pressure readings except when they are used under strictly standardized and constant conditions; hence, their use is not recommended. Doppler devices, which amplify the Doppler signal from flowing blood, are also used with standard sphygmomanometers and obviate the need for a stethoscope. They are especially useful in taking infants' blood pressure or in situations where the auscultatory signal is difficult to hear.

Observer

Every person who makes indirect blood pressure measurements must be carefully trained and made aware of the potential pitfalls. Several excellent programs, some using videocassettes, provide standardized instruction, training, and testing of observers.[21,22] Unfortunately, many health care professionals do not participate in regular retraining programs to improve and reassess their skills in blood pressure measurement, despite considerable variability in their knowledge, skill, and technique. The observer must be able to concentrate on the task and have reasonably good eyesight, hearing, and manual dexterity as well as hand-eye-ear coordination. The observer must be comfortably positioned to be able to (1) inflate and deflate the bladder in the cuff gradually, (2) see the manometer and the meniscus of the column of mercury or the indicator needle on the aneroid scale, (3) hear the Korotkoff sounds, differentiating them from extraneous noises, (4) make note of and remember the level of the pressure at the first appearance, at muffling, and at the disappearance of the Korotkoff sounds, while continuing to deflate the occluding cuff, and (5) remember and record the systolic and diastolic pressure (Phases IV and V) accurately to the nearest 2 mm Hg.

Observer errors can also result from subconscious biases. Terminal digit preference is caused by the tendency to round pressure readings off to numbers ending in zero instead of recording