

Blood Pressure (BP) Measurements in Adults

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Uncontrolled high blood pressure is present in every 3rd person in the American community and is attributed to be a major risk factor for progression of chronic kidney disease, coronary artery disease, and stroke. Therefore, blood pressure recording is the most common measurements at home and by healthcare professionals in all of clinical medicine. It might come as a surprise that majority of recordings are done in a less than ideal circumstances and consequently performed inaccurately.

BP measurements using mercury sphygmomanometer by a trained health care professional is the gold standard for clinical assessment of blood pressures. The appearance of the 1st Korotkoff sound signals the systolic blood pressure and the disappearance of the 5th sound denotes the diastolic blood pressure. The hypertension experts believe and have increasing evidence to suggest that this method frequently either over diagnose hypertension or fail to recognize masked hypertension (blood pressure that is normal in the physician's office setting but high at other times including at home). The four commonly recognized reasons for this are:

- Avoidable inaccuracies in the methods,
- The inherent variability of blood pressure; and
- The tendency for blood pressure to increase in the presence of a health care professional (the so-called white coat effect).
- Failure to standardize blood pressure measurement dos and don'ts.

It is believed and also to some extent evidence based that the health care providers including physicians often do not follow established guidelines for blood pressure measurement. It is also suggested that when BP measurements are taken as it should be, clinic readings correlate much more closely with the objective blood pressure measures. Unfortunately, busy office or clinic readings are a very poor reflection of true blood pressures, not only because of the lack of standardization and inaccuracies of measurement technique but also because of minute to minute variability of blood pressure, a small number of readings only provides a crude estimate of the average BP.

For accurate interpretation of blood pressure readings, one needs to be aware of following issues with blood pressures:

- Diurnal variation
- Transient changes due to stressors and/or extraneous factors
- The sustained average blood pressure, what we call as hypertension that is associated with morbid events
- Non-dippers, whose pressure remains high at night are at greater risk for cardiovascular morbidity than dippers

JNC 7 classification of blood pressure is given in table 1 below.

BP Classification	SBP mm Hg*	DBP mm Hg*
Normal	<120	<80
Prehypertensive	120–139	80–89
Stage 1 hypertension	140–159	90–99
Stage 2 hypertension	≥160	1≥100

In this write up I will discuss the issues that relates to devices used for measuring blood pressure. In subsequent write ups, other issues will be discussed.

Blood Pressure Measurement Devices

1. Auscultatory method (Mercury, and Aneroid)
2. Oscillometric automated devices Technique

This method was first discovered by Korotkoff in 1905 and is still being used for measuring blood pressure. A cuff is inserted over the upper arm. The cuff is inflated such that the pressure reaches over the systolic pressure to occlude the artery. At this time the pulse over the artery disappears. The next step is to gradually deflate the cuff to reestablish the pulsatile blood flow. This is ascertained by listening to the start of the Korotkoff sound through the bell of a stethoscope placed right over the brachial artery just below the lower edge of the cuff, which typically is close to the bend of the elbow. When the sound is first heard, it is the systolic pressure. As the deflation of cuff continues, the sound becomes louder, and then gradually diminishes to a very weak sound. Approximately 5 to 10 mm later, the sound altogether disappears. The diastolic pressure is when the sound suddenly disappears, not the point at which the sounds become weaker.

The Korotkoff sounds have been classified as having 5 phases:

- 1.Phase I - appearance of clear sounds corresponding to the appearance of a palpable pulse
- 2.Phase II - sounds become softer and longer
- 3.Phase III - sounds become crisper and louder
- 4.Phase IV - sounds become muffled and softer
- 5.Phase V - sounds disappear completely. The fifth phase is recorded as the last audible sound.

A combination of turbulent blood flow and the arterial wall oscillations create sounds. There is no disagreement that in the auscultatory method, the onset of phase I corresponds to the systolic pressure and even after realizing that this method tends to underestimate the systolic pressure compared to direct intra-arterial measurement. For a long time in the past, some experts considered weakening or muffling of sounds (phase IV) corresponded to diastolic pressure. But, based on diastolic pressures determined by direct intra-arterial measurements, the true diastolic pressure occurs after the complete disappearance of sounds (phase 5). Now the general consensus is to use the fifth phase as depicting diastolic pressure. Nevertheless, this approach cannot be reliably used for situations of high output states where the sounds do not disappear even until zero, like the example of blood pressures in pregnant women, patients on hemodialysis with A-V fistulas, valvular leaks such as aortic regurgitation. It is reassuring to know that most major clinical trials have been conducted using phase 5 as the diastolic blood pressure. Nevertheless, it is apparent that compared to direct measurement of intra-arterial pressures, the auscultatory method tends to give values for systolic

pressure that are lower and the diastolic values that are higher.

The mercury sphygmomanometer has always been regarded as the gold standard for clinical measurement of blood pressure. Because of the concerns of mercury exposure, use of mercury sphygmomanometer has significantly declined in the past decade.

The aneroid instrument is composed of a mechanical system of metal bellows that responds to cuff pressure and a series of levers that register pressures on a circular scale. Because of complex design, mechanical failure and aging of parts result in failure to maintain its stability over time. Therefore, these instruments tend to be less accurate over time than mercury sphygmomanometers. Moreover, they require frequent calibrations. Recent technological advances appear to overcome some of the earlier deficiencies.

The Oscillometric Technique:

This technique was first demonstrated by Marey in 1876. In later years, further advances in this area demonstrated that when the oscillations of pressure in a sphygmomanometer cuff are recorded during gradual deflation, the point of maximal oscillation corresponds to the mean intra-arterial pressure. As we know, the oscillations begin above systolic pressure and continue below diastolic. In the design of instruments, the systolic and diastolic pressures are estimated indirectly by an empirically derived equation. In this technique it is not necessary to place any device over the brachial artery. The oscillatory recordings are devoid of external sound interference. The most devices are user-friendly and require no special training in using them.

The major concerns with the technique are:

1. The influence of factors other than blood pressure on amplitude of the oscillations. This is especially a concern in elderly who tend to have stiff arteries and wide pulse pressures. In such cases, the equations that are used to estimate systolic and diastolic pressures by necessity have to be different than the one used in younger individuals. Consequently, the mean arterial pressure may be calculated lower than the true intra-arterial pressures and could easily introduce inaccuracies in the recording of blood pressures.
2. In those with considerable movement artifact, such as individuals with tremors, during physical activities, these devices are not reliable.
3. It is said the cuffs deflate at a manufacturer-specific “bleed rate” and is inflexible and matched to an assumed fixed regular pulse. These assumptions are incorporated in the equation used to determine systolic and diastolic pressure in individuals with severe tachycardia.

However, studies comparing these devices with intra-arterial and Korotkoff sound measurements have shown close agreements. Despite the concerns raised above, devices based on the oscillometric technique have been used extensively for home monitor and 24-hour ambulatory monitor. Oscillometric devices are also used now in a clinic setting.