

Review Article

Obtaining Accurate In-Office Blood Pressure Readings

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Abstract

The ability to consistently obtain accurate blood pressure measurements in the office setting has significant implications for the categorization, risk stratification, and treatment of hypertension at both a societal and individual level. However, obtaining consistently accurate assessments of blood pressure in the outpatient setting is a difficult task. Currently, there is a significant controversy in regard to the optimal method for measuring outpatient blood pressure given the multitude of devices, techniques, and practice guidelines available. In this review, we discuss the pros and cons for different measurement techniques, the most common sources of clinical error, and current guideline recommendations for the optimal timing and method for reliable outpatient blood pressure assessment.

Key words: Diagnostic techniques and procedures, blood pressure determination, blood pressure monitoring, ambulatory

Introduction

Nearly half of adults currently living in the United States have hypertension.^[1] Untreated, long-standing hypertension can lead to significant detrimental health effects such as chronic kidney disease, atherosclerosis, heart failure, stroke, retinopathy, and more.^[2,3] The American College of Cardiology/American Heart Association 2017 Hypertension guidelines recommend a blood pressure of 140/90 as the cutoff for initiation of hypertension treatment.^[4] The ability to consistently obtain accurate BP measurements has significant implications for the categorization, risk stratification, and treatment of hypertension at both a societal and individual level. The gold standard for measuring a patient's true, intraluminal blood pressure is an intra-arterial device. However, this is not practical for an outpatient clinical setting given the invasive nature, practical considerations, and associated risks. Therefore, there are a number of less invasive techniques that have been developed to estimate a BP measurement.

The use of non-invasive techniques is associated with many potential pitfalls that could make BP estimates exceedingly inaccurate, such as the clinical technique, patient setting, or device itself. In this brief review, we describe common sources

of error and proper technique for taking non-invasive blood pressure readings, the different types of devices used to estimate BP, and the most recent recommendations highlighting the utility of automated office BP (AOBP) readings.

Clinical Importance and Sources for Error

There is much controversy in regard to the optimal method for obtaining outpatient BP measurements given the multitude of devices, different techniques, and large discrepancy in adherence to recommended guidelines. Sources of error include patient considerations (recent food intake and movement during measurement), device-related factors (inaccurate calibration), or procedure factors (talking during procedure, inappropriate positioning, or cuff sizing).^[5] Studies have found that incorrect technique is common and leads to large discrepancies in single BP readings, thus limiting the clinical utility of a single measurement in the diagnosis and treatment of a hypertensive patient.^[5,6]

The difficulty in obtaining accurate and precise BP measurements is demonstrated in studies that have shown the variability in BP measurements acquired in the same setting.

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Handler *et al.* analyzed U.S. national data from 22,641 adults and found that 35% of patients diagnosed with hypertension on a single BP measurement during an initial office visit actually had an systolic blood pressure (SBP) less than the hypertensive threshold when averaged over three visits.^[7] Similarly, Powers *et al.* found that at least five BP measurements were required to be 80% certain that the true SBP was below the HTN cutoff of 140 mmHg in men taking antihypertensive medications.^[8] The 2017 American College of Cardiology/American Heart Association joint task force on clinical practice guidelines recommend at least two separate measurements per clinic visit given these large discrepancies in BP estimates in the same sitting.^[4]

Proper Cuff Size

Using a blood pressure cuff that is appropriately sized for the patient is essential to obtain an accurate BP estimate. Appropriate cuff size should be determined based on the patient's arm circumference [Table 1].^[9] Using a blood pressure cuff that is too small for the respective patient is the most common source of error during BP measurements.^[10] Undersized cuffs are not able to appropriately transmit the full pressure generated in the cuff's bladder to the patient's brachial artery. Therefore, the cuff's pressure is higher than the true luminal pressure, leading to a potential significant overestimation of the true BP.

Auscultation Technique

In terms of how to obtain non-invasive BP estimates, the auscultation method is the traditional technique that has been one of the most commonly used methods since its initial introduction by Dr. Korotkoff in 1905.^[11,12] This technique relies on an observer listening for the appearance and disappearance of "Korotkoff sounds" while slowly releasing compression of

the brachial artery and watching pressure readings through a sphygmomanometer.

The scientific statement from the American Heart Association^[6] outlines the recommended technique for measuring blood pressures during outpatient office visits. The key points to patient setup to ensure an accurate BP estimate include a quiet environment, an appropriately sized cuff for the patient, and the correct placement of the BP cuff at the level of the patient's right atrium [Table 1]. The brachial artery should be palpated in the antecubital fossa and the center of the cuff bladder (typically marked by the manufacturer) should be placed over this arterial pulsation on the patient's bare upper arm. The lower end of the cuff should be 2–3 cm above the antecubital fossa to allow for sufficient room for the placement of the stethoscope. The bell of the stethoscope should not be in contact with the BP cuff to avoid artificial noise.^[13] Inflate the cuff at least 30 mmHg above the pressure at which the radial pulse disappears and then slowly releases pressure at a rate of 2 mmHg per second (or per heartbeat if patient has very slow heart rate). Listen for the five key phases of Korotkoff sounds: (1) Sudden appearance of sharp tapping sounds (systolic blood pressure), (2) swishing, (3) regular and louder sounds, (4) abrupt muffling of sounds, and (5) loss of sounds (diastolic blood pressure).

Traditional sphygmomanometers rely on a column of mercury to measure pressure, providing simplicity in their design. However, many states are banning the use of such devices due to environmental concerns in regard to the toxicity of mercury.^[14] Aneroid designs eliminate the use of mercury by utilizing metal bellows that respond to variations in pressure within the system to rotate gears that turn a calibrated dial. However, these fine-tuned systems are susceptible to error if handled harshly, and it is recommended that they be calibrated every 2–4 weeks for handheld devices or 6 months for wall-mounted units.^[15] More recently, there are hybrid designs that are similar to the traditional sphygmomanometer mechanism but replace the mercury column with an electronic pressure gauge. Studies have demonstrated these hybrid models provide a reliable alternative, but the frequency with which they should be calibrated remains unknown.^[16,17]

Table 1: Key points to ensure proper technique during blood pressure measurement^[6]

Key points
Appropriate environment
Quiet setting without distractions
Patient should refrain from talking
Appropriate cuff size
Too small will overestimate, too large WILL underestimate
Cuff length should be 75–100% of patient's arm circumference
Cuff width should be 37–50% of patient's arm circumference
Suggested cuff sizes based on arm circumference: ^[9]
"Small adult:" 22–36 cm
"Adult:" 27–34 cm
"Large adult:" 35–44 cm
"Adult thigh:" 45–52 cm
Appropriate position
Seated is preferred (supine is also acceptable)
BP cuff should be at the level of the right atrium

BP: Blood pressure

Oscillometric Technique

An alternative to the auscultation method is the use of an oscillometer. These devices automate the BP measurement by sensing the intraluminal waveforms and evaluating the amplitude of BP oscillations on the arterial wall to calculate estimates for systolic and diastolic BP.^[18] These devices all use proprietary algorithms unique to each manufacturer, which can be updated at any time with no obligations to report such changes. Therefore, it is highly recommended to only use a device that has been independently validated.^[6] Oscillometric devices may be a cost-effective alternative to auscultation by obviating the costs associated with training staff in manual blood pressure measurement.^[14]

Automated Office Blood Pressure (AOBP) Readings

A potential advantage of utilizing an oscillometer rather than the auscultatory technique is that the devices allow for fully automated BP measurements without the need for an observer to be present. There are numerous studies that have validated the use of automated BP devices with either an observer present or patient alone and in multiple locations throughout an outpatient office.^[19-23] AOBP also decreases the reliance on an observer's skills, negates the white coat effect if the patients are left completely unattended,^[19] and reduces calibration issues with auscultatory sphygmomanometers.

There is a plethora of studies that have demonstrated AOBP measurements to be more closely correlated to ambulatory BP estimations than auscultatory office BP measurements.^[20,24-27] These include the large conventional versus automated measurement of BP in the office (CAMBO) study, which demonstrated a smaller difference between awake ambulatory BP measurements and AOBP estimates than with auscultatory measurements.^[27] Moreover, AOBP has also been shown to be closely associated with subclinical potential cardiovascular disease assessed by intima-media thickness of the carotid arteries^[28] and LV mass index.^[29]

Given this net positive data in favor of unattended AOBP, the Canadian guidelines adopted the AOBP technique as the preferred method for assessing BP in an outpatient setting.^[30] Since the recommendation, there is early evidence from a Canadian national survey that AOBP has been widely adopted in primary care offices in Canada with minimal increases to staff time or effort.^[31] The potential drawback of AOBP is the reliance on "black box" devices that utilize proprietary algorithms to estimate BP that can be changed without regulation. Therefore, it is important to stress again that it is recommended to only use devices that have been validated against alternative BP estimation techniques in independent testing.^[6]

Alternatives to Measure BP

Despite differences between manual and automated blood pressure methods, both use an inflatable blood pressure cuff to measure pressure. Pain and discomfort caused by the repeated cuff inflation can cause distress for the patient, which can further influence the blood pressure measurement obtained. Alternatively, innovative cuff-less methods have been developed to prevent these inaccuracies. "Checkme," for example, is a cuff-less device that works by measuring the time interval of a pressure wave between two pulse points, which has been found to be indirectly correlated with blood pressure.^[32] The handheld device includes other vital measurements as well and allows patients to use it independently in any setting. Further research is needed for these experimental designs.

As new devices and methods become available, regulation and guidelines need to be adjusted to ensure proper calibration and usage. The European Society of Hypertension International Protocol (ESH-IP) 2010 revision provides a methodology to

standardize the technical requirements for the testing of any new proposed device.^[33] This includes the comparison of the device measurements to observed manual blood pressure measurements using the auscultatory method with a standardized technique that includes multiple repeated measurements, to ensure the accuracy and precision of any new device. The Association for the Advancement of Medical Instrumentation also created standardized protocols for new device testing, including stipulations for non-traditional devices that may use sense or display pulsations, flow, or sound measurements to estimate blood pressure.^[34]

Conclusion

Blood pressure measurements have a significant effect on patients' lives, as a diagnosis of hypertension is often accompanied by suggestions for lifestyle changes and prescriptions for life-long medications. The importance of accurate and reliable blood pressure measurements in the clinical setting is imperative in providing comprehensive, patient-centered care. Obtaining consistently accurate assessments of blood pressure in the outpatient setting is a difficult task. There are a variety of factors that affect the accuracy of a patient's baseline blood pressure, including setting, time of day, user error, and device calibration. All of these factors need to be considered when forming a diagnosis of hypertension. Established guidelines for the correct technique should be followed when taking a manual blood pressure measurement. AOBP should be considered as a promising alternative that allows for multiple automated readings, negates any potential white coat effect, and can be implemented in a clinical setting without significant disruption to current workflow.

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