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ONLINE EXCLUSIVE

Avoiding missteps in BP measurement

Making sure a patient is seated properly is just one way to ensure an accurate measurement. But steering clear of certain methods of measurement in particular patient populations is also important.

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Blood pressure (BP) measurement is an essential component of the physical examination. The information gleaned through this simple but vitally important assessment provides a basis for critical decisions about diagnosis, prognosis, and therapy in a variety of health care settings. In the emergency department, it helps guide resuscitation efforts; in the intensive care unit, it helps to identify the deteriorating patient and guide vasopressor drug titration; in the ambulatory office setting, it helps to identify hypertension and the need for antihypertensive therapy.

In the office setting, inaccurate BP measurement can have profound effects. An overestimation by only 5 mm Hg would result in an erroneous diagnosis and unnecessary treatment of hypertension for about 27 million patients—entailing medication costs, potential adverse effects, and psychologic issues associated with this diagnosis. Conversely, underestimation by 5 mm Hg would miss about 21 million patients who actually have hypertension.[1]

Why accurate BP measurement matters so much

About 75 million adults in the United States have high BP,[2] which costs the nation $46 billion annually in health care services, antihypertensive medications, and missed days of work.[3] Among US adults ages 20 or older, the age-adjusted prevalence of hypertension is estimated to be 34%, equivalent to 85.7 million adults.[4]

Defining hypertension. For the general population, the Eighth Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-8) defines hypertension as a BP of 140/90 mm Hg or higher in adults younger than 60 and a BP of 150/90 mm Hg or higher in adults ages 60 or older. For patients with comorbid hypertension and diabetes, JNC-8 recommends pharmacologic treatment when BP is 140/90 mm Hg or higher, regardless of age.[5]

Accurate measurement of BP provides the rational basis for the management of hypertension, which in turn may decrease the risk for stroke, congestive heart failure, and other cardiovascular diseases. Several investigators[6-8] have observed that differences in interarm systolic BP are associated with an increased risk for peripheral vascular disease, stroke, and other cardiovascular problems.

Multiple factors impact accuracy; some might surprise you

A number of factors may influence the accuracy of BP measurement in the office; these are generally classified as related to the *patient*, the *observer*, the technique or *procedure*, or the *equipment* used. A recent systematic review by Kallioinen et al[9] empirically evaluated 29 potential sources of inaccuracy in the measurement of adult resting BP. Among them were

Patient-related: Recent meal or alcohol intake; recent caffeine or nicotine use; full bladder distention; cold exposure; white-coat effect. Given the simplicity of assessing for these influences, it is worthwhile for office staff to ask patients, prior to the recommended 3 to 5 minutes of rest before BP measurement, if they were rushing to make their appointment, need to void their bladder, or have consumed food or drink or used tobacco within the past 30 minutes.

Observer-related: Hearing deficit; terminal digit bias (ie, preference for rounding BP reading to a specific end digit, eg, 0); measurement of diastolic BP at Korotkoff phase IV rather than phase V.

Procedure-related: Patient's body position (eg, standing vs supine; legs crossed at knee; unsupported back or arm; arm lower than heart level); incorrect size or placement of cuff; talking during measurement (the content of conversation may influence results); and reliance on a single BP measurement.

Equipment-related: Device model bias; device calibration error.

As reported by Kallioinen et al[9], the magnitude of these potential errors ranges from small to large in both the positive and negative direction for both systolic and diastolic BP, and several sources of error are potentially bidirectional. For example, talking during BP measurement may result in an increase in systolic BP of 4 to 19 mm Hg and in diastolic BP of 5 to 14.3 mm Hg; measurement of diastolic BP at Korotkoff phase IV rather than phase V significantly increases diastolic BP by 12.5 mm Hg; and recent alcohol intake can affect systolic BP by –23.6 to +24 mm Hg and diastolic BP by –14 to +16 mm Hg. Overall, the researchers found significant directional effects for 27 of the 29 potential sources of error, ranging from a mean –24 mm Hg to +33 mm Hg error for estimating systolic BP and a mean –14 mm Hg to +23 mm Hg for estimating diastolic BP.[9]

The USPSTF, the UK's National Institute for Health and Clinical Excellence, and other groups endorse ambulatory BP monitoring as the optimal method for BP measurement.

Careful adherence to guidelines ensures accurate BP measurement

Adequate training and standardized procedures can target and mitigate many of the identified sources of error; accordingly, all clinical staff responsible for obtaining a patient's BP measurement should be trained not only in the correct method for accurate measurement but also in the identification of factors that may introduce errors.

The American Heart Association (AHA) recommends that BP be measured in both arms at the initial evaluation, with the higher measurement used for monitoring BP. The AHA also recommends obtaining at least 2 readings at least 1 minute apart and averaging them as the patient's BP.[10] Other research recommends using a fully automated sphygmomanometer to take multiple readings with the patient resting quietly alone in either the exam room or the waiting room[11] as an effective and efficient method for accurate BP averaging.

The 2 principal noninvasive methods of BP measurement are the manual auscultatory technique and the oscillatory technique. Because of its simplicity and relative degree of accuracy (when correctly performed), the auscultatory measurement remains common in everyday medical practice. Remarkably, it is one of only a few techniques for clinical examination of patients that has remained relatively unchanged since it was introduced by the Russian physician and scientist Nikolai Sergeevich Korotkoff in 1905.[12] However, accurate performance of the auscultatory method requires adequate training and experience.

In contrast, automated oscillometric BP measurement is easily performed and requires minimal training. However, it is important to note that any condition altering oscillation amplitude or regularity (eg, arterial wall stiffness or cardiac arrhythmia) will produce erroneous results, and the reading must be confirmed by auscultatory measurement.[13,14]

Auscultatory methods of BP measurement

The mainstay of clinical BP measurement has been auscultatory methods to detect the Korotkoff sounds, using a stethoscope and either mercury, aneroid, or "hybrid" sphygmomanometers. Traditionally, the mercury device was the "gold standard," but the widespread ban of mercury in health care settings has now all but eliminated its use.

Aneroid gauge sphygmomanometers have a metallic spring and a metal membrane that flexes elastically to translate pressure signals from the cuff and operate a needle in the gauge. Owing to their complexity, these devices require regular recalibration, since inaccurate results may occur anytime the needle does not rest on 0 before use.

The newer hybrid sphygmomanometers have an electronic transducer in place of a mercury column; BP measurement is performed in the same fashion as with a mercury device, using a stethoscope and auscultation for the Korotkoff sounds.

Variations in technique for BP measurement can result in significantly different readings. In 2005, the AHA published recommendations for BP monitoring to increase the accuracy of in-clinic measurements.[10] Recommendations for accurate BP measurement include:

Patient preparation. The patient should be seated in a chair with his or her back supported, legs uncrossed, and feet flat on the floor. The patient's bare arm should be supported such that the midpoint of the upper arm is at heart level. An appropriately sized cuff (ie, bladder encircles 80% of the arm for an adult or 100% of the arm for a child younger than 13 years) should be secured around the bare upper arm and the bladder centered over the brachial artery, with the lower edge of the cuff about 2 cm above the antecubital fossa.[10]

Technique. The cuff is inflated while palpating the radial artery to the approximate systolic pressure (ie, the point at which the radial pulse is no longer palpated). The bell of the stethoscope is placed just proximal and medial to the antecubital fossa and the cuff is inflated another 20 to 30 mm Hg above the point at which the radial pulse is no longer felt. The cuff is deflated at a rate of about 2 mm Hg per second.[10]

BP recording. The systolic BP is recorded at the appearance of the Korotkoff sounds (phase I) for an auscultatory measurement. The diastolic BP is recorded at the disappearance of the Korotkoff sounds (phase V) in adults and at the muffling of sounds (phase IV) in children for an auscultatory measurement.[10]

Oscillometric methods of BP measurement

The auscultatory methods of BP measurement are gradually being replaced by oscillometric techniques that are better suited to automated methods of measurement. When oscillations of pressure in the gradually deflating bladder cuff are sensed and recorded, the point of maximal oscillation corresponds to the mean intra-arterial pressure.[15] The oscillations sensed are vibrations in the arterial wall that are detected and transduced to an electric signal, producing a digital readout, and correspond approximately to the systolic pressure and continue below the diastolic pressure. The actual systolic and diastolic pressures are indirectly estimated according to a proprietary, empirically derived algorithm that differs from 1 manufacturer to another.

Validated oscillometric techniques have been successfully used in ambulatory BP monitors, which record pressure at regular intervals (typically 20 to 30 minutes) over a 24-hour period while patients perform normal daily activities, including sleep. The US Preventive Services Task Force[16], the UK's National Institute for Health and Clinical Excellence[17], the European Society of Hypertension[18], and the Canadian Hypertension Education Program[19] collectively endorse ambulatory BP monitoring as the optimal method for BP measurement.

The oscillometric method has also been used for automated office BP measurement, which averages multiple BP readings recorded with a fully automated device while the patient rests alone in a quiet room in clinic. Compared with conventional auscultatory office BP measurement, this method has been promoted to provide a more standardized BP measurement by reducing observer error and the "white coat" effect.[20-22]

There are some limitations to oscillometric methods. The amplitude of oscillations is influenced by factors other than BP, notably, arterial wall stiffness. Therefore, in older patients[13] or those with diabetes[14] who have reduced arterial wall elasticity, oscillometric BP measurements overestimate systolic pressure and underestimate diastolic pressure. In contrast, acutely ill patients, par-

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ticularly those with hypovolemia and more compliant arterial walls, may have significant underestimation of BP by oscillometric techniques.[23] In patients with peripheral arterial disease, calcified leg vessels can affect the diagnostic accuracy of oscillometric measurement of the ankle-brachial index (ABI).[24] A meta-analysis reported that in patients with atrial fibrillation, oscillometric measurement accurately assesses systolic BP but not diastolic BP, and therefore it may be inappropriate for office measurement of BP in these patients.[25] Other studies have reported that atrial fibrillation does not significantly affect the accuracy of oscillometric BP measurement if 3 repeated measurements are performed.[26,27]

Moreover, the algorithms used in these devices are proprietary trade secrets that can be modified by the manufacturer at any time without notice. Therefore, different devices—and even different models from the same manufacturer—may function differently. Only devices calibrated using a validated protocol should be used.[10,28] There are currently 4 unique protocols for validation of BP devices, although an international collaborative group recently published recommendations for a universal protocol for validation of BP measurement devices.[29]

If oscillometric BP measurement is performed in patients with atrial fibrillation, at least 3 repeated measurements should be done to improve accuracy.

The takeaway

Accurate office BP measurement is essential for patient evaluation and provides the basis for critical decisions about diagnosis, prognosis, and treatment of hypertensive disease. It is imperative to control for factors that may introduce error in BP determination by using a standard protocol and calibrated BP measurement equipment.

Both manual auscultatory and oscillometric methods of measurement are appropriate for office assessment, but oscillometric evaluation is inappropriate for patients with severe atherosclerotic disease, peripheral arterial disease (for ABI), or small arm circumference. If oscillometric BP measurement is performed in patients with atrial fibrillation, at least 3 repeated measurements should be done to improve accuracy. Automated oscillometric BP assessment that records multiple measurements in the quietly resting patient has been promoted to provide a more standardized BP measurement by reducing observer error and the "white coat" effect. Ambulatory oscillometric BP monitoring has been widely endorsed as the optimal method for BP measurement. JFP

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