CME CREDIT ***EDUCATIONAL OBJECTIVE:*** Readers will list the advantages of using automated devices for measuring blood pressure in the office or clinic

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Taking blood pressure: Too important to trust to humans?

ABSTRACT

The measurement of blood pressure in the physician's office is subject to a number of observer errors and also to the "white-coat effect." Automatic devices that measure blood pressure without a human observer in the room can eliminate many of these problems. We argue for greater use of these devices in the physician's office.

KEY POINTS

The white-coat effect, ie, the tendency of many patients to have higher blood pressure in the presence of medical personnel than in their own environment, can lead to inappropriate diagnosis of hypertension and unnecessary treatment.

Out-of-office blood pressure correlates better with cardiovascular risk than does the blood pressure in the physician's office, but ambulatory monitoring is costly and not widely available, and few physicians recommend self-measurement at home.

Several available devices can take a series of blood pressure measurements at preset intervals while the patient sits alone in the examination room, eliminating the white-coat effect.

The mean of five automatic readings taken at intervals of 1 or 2 minutes correlates well with the mean value while awake on ambulatory monitoring.

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THE REALITY of blood pressure measurement is that human beings do not do it very well. The time has come to delegate this job to machines that can do it better.

Several automatic devices are available. Used in physicians' offices and in patients' homes, they can eliminate some types of observer error as well as the "white-coat effect," ie, the tendency of some patients to have higher blood pressure when medical personnel are present than in their natural environment. Since a difference of only a few millimeters of mercury can affect the physician's decision to start or to modify treatment, measurements that more accurately reflect a person's average blood pressure are to be desired.

In the following pages, we review the problems that plague blood pressure measurement by human observers, and we describe the advantages of automatic devices.

SHORTCOMINGS OF OFFICE BLOOD PRESSURE MEASUREMENT

For decades, large surveys have provided invaluable information on the prevalence of hypertension, its relationship to cardiovascular disease, and the benefits of treating it.[1–3] Unfortunately, the percentage of hypertensive patients whose blood pressure is under control has remained low despite our increased knowledge about hypertension's diagnosis and therapy.[4]

In these surveys, blood pressure was measured by auscultation by human observers using mercury or aneroid sphygmomanometers, and most physicians still use this method in clinical practice. But in spite of multiple guidelines for accurate measurement of blood pressure in

the office, the overall accuracy and reproducibility of office blood pressure measurements remain poor.[5–7]

The accuracy of blood pressure measurement with aneroid and mercury manometers is affected by a number of observer errors and patient factors.[8,9]

Observer errors

Failure to prepare the patient. National guidelines[5] state that before having their blood pressure taken, patients should be allowed to sit quietly for at least 5 minutes, which often does not happen. Another error is that clinicians rarely discourage patients from smoking cigarettes or drinking coffee in the 30 minutes prior to measurement.

Equipment and layout problems. Equipment should be properly calibrated and validated.[5] However, even if the sphygmomanometer is periodically calibrated, too often it is mounted on the wall adjacent to the examination table in the examination room, making it difficult to provide a comfortable seat with back and arm support during the reading. The measurement should be done with the patient sitting in a chair (not on an examination table), with feet on the floor and the arm supported at the level of the heart. If the forearm is not supported in the horizontal position and with the cuff at heart level, the blood pressure and heart rate tend to be higher.[10] Further, the diastolic blood pressure and heart rate may be misleadingly low with the patient supine rather than seated,[11,12] so readings should be taken with the patient sitting.

A small cuff on a large arm gives a falsely high reading

Miscuffing, ie, the use of a blood pressure cuff that is too large or, more often, too small for the patient's arm, is a common source of error. The cuff bladder should encircle at least 80% of the arm.[5] However, some offices do not have a large blood pressure cuff for overweight patients or a pediatric cuff for children or adults with arms of small circumference. It is recommended that a large blood pressure cuff be used routinely in adults, since a smaller cuff gives falsely high readings in people with large upper arms (circumference > 29 cm).[13,14]

Digit preference. Many physicians round off the blood pressure to the nearest 5 or 10 mm Hg. This problem may go along with:

Deflating the cuff too rapidly.

Talking to the patient while taking the blood pressure can contribute to higher readings.[9]

Not taking enough readings. Ideally, at the initial visit, blood pressure should be measured in both arms with the patient seated, and another reading should be taken with the patient standing. The arm with the higher pressure should be used for subsequent readings. Physicians should not make any treatment decisions based on blood pressure during an initial clinic visit, and at least two readings should be taken even on subsequent visits. However, owing to time constraints in busy clinical practices, treatment decisions are often based on single readings or on multiple readings on a single visit.

Discrepancies between observers. The blood pressure readings obtained by the nurse or medical assistant may differ significantly from those obtained by the physician. These differences can be large enough to affect treatment decisions,[15,16] and they can be partially corrected by adequate training of all medical personnel who take blood pressure, doctors as well as nurses.

Given that time is tight in busy clinical practices and a trained blood pressure nurse or technician is usually not available, we will probably not see any significant improvement in the accuracy of blood pressure measurement using older technology and current physician practices.

The white-coat effect

Most patients have a higher level of anxiety, and therefore higher blood pressure, in the physician's office or clinic than in their normal environment (as revealed by ambulatory monitoring or home blood pressure measurements), a phenomenon commonly called the white-coat effect.

Several factors can increase this effect, such as observer-patient interaction during the measurement. The effect tends to be greatest in the initial measurement, but can persist through multiple readings by the doctor or nurse during the same visit.

Whether the white-coat effect is due purely to patient anxiety about an office visit or to a conditioned response has been a point of interest in clinical studies. Regardless, it may

result in the misdiagnosis of hypertension or in overestimation of the severity of hypertension and may lead to overly aggressive therapy. Antihypertensive treatment may be unnecessary in the absence of concurrent cardiovascular risk factors.[17]

"White-coat hypertension" or "isolated office hypertension" is the condition in which a patient who is not on antihypertensive drug therapy has persistently elevated blood pressure in the clinic or office (> 140/90 mm Hg) but normal daytime ambulatory blood pressure (< 135/85 mm Hg).[18] Since patients may have an elevated reading when seen for a first office visit, at least several visits are required to establish the diagnosis. Multiple studies have suggested that white-coat hypertension may account for 20% to 25% of the hypertensive population, particularly in older patients, mainly women.[19,20]

Both white-coat hypertension and the white-coat effect can be avoided by using an automatic and programmable device that can take multiple readings after the clinician leaves the examination room (more about this below).[21]

MEASURING BLOOD PRESSURE OUTSIDE THE OFFICE

Recent studies have reported that the information obtained by 24-hour ambulatory blood pressure monitoring and by self-measurement of blood pressure in the home more accurately reflects the patient's risk of future cardiovascular events than do conventional blood pressure measurements taken in the physician's office.[22–24] Current national guidelines recognize this pattern and the frequent measurement inaccuracies observed in clinical practice, and they are recommending including out-of-office measurements in the diagnosis of hypertension.[25,26]

Ambulatory monitoring provides the most accurate measurement of out-of-office blood pressure. With ambulatory monitoring, the normal mean daytime pressure is considered to be lower than 135/85 mm Hg, in contrast to the 140/90 mm Hg cutoff used in the physician's office with standard aneroid or mercury devices.

Self-monitoring of blood pressure at home has now become widely available with single-measurement oscillometric devices. (Oscillometric means that these devices measure the blood pressure by sensing the oscillations in pressure in the cuff induced by the pulsation of the brachial artery, as opposed to auscultating the Korotkoff sounds.) Blood pressures lower than 135/85 mm Hg outside the clinician's office are considered normal with these devices.

However, despite its proven value, ambulatory monitoring is neither widely available nor cost-effective for the long-term management of hypertension. Furthermore, few physicians recommend that patients take their blood pressure at home, although the information obtained can be of significant value in the patient's long-term management.

AUTOMATED MEASUREMENT IN THE OFFICE

In recent years, several automated oscillometric sphygmomanometers have been developed for measuring blood pressure in the office, and more are on the way. These devices can be programmed to take multiple readings without a clinician observer in the examination room, thus reducing the white-coat response.

We will probably not see any significant improvement in the accuracy of blood pressure measurement using older technology and current practices

Omron (Kyoto, Japan) makes several devices, including the HEM-907 and the HEM-705, that have been used in the clinical setting.[21,27–29] They can be programmed to take two or three readings at intervals of 1 to 2 minutes, with up to 5 minutes before the first reading. Unfortunately, data were not recorded with the patient alone in the room in many studies of the Omron devices, even though the devices meet national and international standards for accuracy.

The Microlife Watch BP Office (Microlife, Widnau, Switzerland) is currently undergoing development.[30]

The BpTRU (BpTRU Medical Devices, Coquitlam, BC, Canada) has enjoyed greater clinical acceptance, since it can take up to five blood pressure readings at intervals of 1 to 5 minutes, and calculates the mean of all five readings, taken with the patient resting comfortably in a quiet room without a clinician present.

The accuracy and durability of the device has been well established. Since the BpTRU

self-calibrates between every blood pressure measurement, periodic calibration has not been required. The device can be placed on a table, mounted on the wall, or mounted on a cart if used in several locations in the office.

At Cleveland Clinic, several departments are using the BpTRU on a daily basis. Soon, we will be able to transfer data directly from the BpTRU to our electronic medical record system.

Studies of the BpTRU device

To date, most of the studies of automated office blood pressure measurement have used the BpTRU with the recording interval set at 1 to 2 minutes.

Myers[31] used the BpTRU device in 50 hypertensive patients. The physician took the patient's blood pressure with a mercury sphygmomanometer while the BpTRU device made the first reading, and then he left the room. The next five readings were taken at 2-minute intervals with the patient alone in the room. The mean initial reading by the machine was 162/85 mm Hg; the reading by the physician was 163/86 mm Hg. The third automatic reading was the lowest (averaging 140/84 mm Hg), and the mean of the five automated readings was 142/80 mm Hg, which was significantly lower than the initial reading obtained by the physician ($P < .001$).

On ambulatory monitoring, normal mean daytime pressure is < 135/85 mm Hg

In another study, Myers et al[32] compared the measurements obtained by 24-hour ambulatory monitoring and by the BpTRU device (the mean of five readings obtained at 1-minute or 2-minute intervals) in 309 hypertensive patients. The mean blood pressure with the BpTRU was 132/75 mm Hg, which correlated well with the mean awake ambulatory blood pressure (134/77 mm Hg; r = 0.62 for the systolic pressure and 0.72 for the diastolic pressure).

We recently reviewed the records of 278 patients seen in our preventive medicine clinic (D.G. Vidt, MD, unpublished data, November 2009). The group included patients with and without established hypertension, and among the hypertensive group, both treated and untreated individuals. We had initially set the device to take readings at 3-minute intervals following the initial nurse-initiated reading. But in view of the recent data on the BpTRU using shorter intervals, we also obtained readings in 51 patients with the device set to record at 2-minute intervals, and then in 72 additional patients at 1-minute intervals. In all three groups, blood pressure had stabilized by the third reading after the clinician had left the room. These observations support those reported by Myers et al.[31,32] Of particular importance is the observation that the white-coat effect dissipates within 2 to 3 minutes after the clinician leaves the room.[33]

The shorter measurement intervals can add up in a busy office practice, in which the time relegated to taking blood pressure is often limited.

In fact, waiting 5 minutes between measurements may allow the patient to become too relaxed and the blood pressure to drop too low vis-a-vis the gold standard, ambulatory monitoring. Culleton and colleagues[34] compared the blood pressure in 107 hypertensive patients as measured four ways: by the referring physician, by a nurse who was trained to adhere to the protocol of the Canadian Hypertension Education Program, by 24-hour ambulatory monitoring, and by the BpTRU (the mean of five readings obtained at 5-minute intervals). The mean measured values were:

- 150/90 mm Hg by the referring physician
- 139/86 mm Hg by the nurse
- 142/85 mm Hg by ambulatory monitoring
- 132/82 mm Hg by the BpTRU device.

Although the BpTRU reduced the white-coat effect and white-coat hypertension, it underestimated the blood pressure, leading to misclassification of hypertension. Using 140/90 mm Hg as the cutoff for whether the patient was hypertensive and using ambulatory monitoring as the gold standard, the BpTRU misclassified more than half of the patients, agreeing with the classification of hypertensive or not hypertensive by ambulatory monitoring in only 48%. The authors recommended that the BpTRU not be set at 5-minute measurement intervals.[34]

WHAT ROLE FOR AUTOMATED READINGS IN THE OFFICE?

Although automatic devices, by enabling the physician to leave the room, can eliminate the white-coat effect and white-coat hypertension, physicians must continue to take care to avoid the other potential errors of office blood pressure measurement addressed earlier in this

review, for example, by positioning the patient correctly and using a cuff that is large enough. These issues can take on more importance as the clinician leaves the patient alone for brief periods during measurements.

In view of its perennial inaccuracies, some experts have suggested that we abandon routine office measurement of blood pressure.[35,36] In its place, ambulatory monitoring would be used for diagnosis and for periodic follow-up. In addition, patients would regularly take their pressure at home with approved, single-measurement oscillometric devices. Unfortunately, in our health care system, periodic ambulatory monitoring for hypertension management would impose a significant financial burden on patients at this time.[37]

Of particular importance is the observation that the mean of five readings with the BpTRU device, obtained at 1- or 2-minute intervals, closely approximates the mean awake blood pressure obtained in the same patient with an ambulatory monitor.[32,38] The ability to obtain readings that correlate exceptionally well with mean daytime ambulatory pressure suggests that this device could well reduce the need for ambulatory monitoring, with its associated cost. The ability to negate the white-coat effect with the use of the BpTRU in the office setting also has particular importance, not only for patient office readings, but for the diagnosis and subsequent treatment of hypertension in individual patients.

Most clinical decisions about the treatment of hypertension are still made on the basis of office determinations of blood pressure. Most office practices still rely on the aneroid manometer or, decreasingly, mercury sphygmomanometers. As noted earlier, although auscultatory blood pressure measurement appears to be simple, it is fraught with a host of observer- or patient-induced errors that not only lead to inaccurate diagnoses, but may also result in the mismanagement of hypertension. Even single-measurement oscillometric devices, now used in a minority of clinical practices, are associated with many of the same measurement issues that lead to overestimation of blood pressure.

We believe the time has come for broader use of oscillometric devices in the outpatient setting. While many available oscillometric devices for use in the home could also be used in the physician's office, they carry the similar disadvantage of providing only a single measurement. The major disadvantage of all single-measurement devices is the continued presence of the clinician during the reading and the associated white-coat effect observed in most patients.

It is highly likely that the next Joint National Committee Report on Hypertension will further emphasize the role of automated blood pressure devices in the outpatient setting. ■

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The white-coat effect dissipates within 2 to 3 minutes after the physician leaves the room

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