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SPECIAL ISSUE

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# Office blood pressure measurement in the 21st century

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## Abstract

Measurement of blood pressure (BP) using the auscultatory method must follow specific rules and conditions to be reliable. Nonetheless, these requirements are often not followed in clinical practice, resulting in inaccurate BP readings. Simply replacing manual sphygmomanometers with an oscillometric device may still produce readings that are associated with a white coat effect. These limitations can be overcome by using an oscillometric sphygmomanometer that automatically records multiple readings with the patient resting quietly and alone, called automated office (AO)BP. AOBP produces office readings with a reduced white coat effect, which are also similar to the awake ambulatory BP. There is also evidence that AOBP is a better predictor of target organ damage than attended office BP. Furthermore, clinical outcome data support AOBP as having both a similar diagnostic threshold as awake ambulatory BP and a lower treatment target. Using AOBP in clinical practice simplifies recording office BP by not requiring an additional period of rest before activation of the device and by not having staff present during the actual measurements. Recent studies have reported that automatic BP measurements taken by staff in research studies with close adherence to guidelines using AOBP devices may produce similar readings to AOBP. Further research is needed to determine the best method for recording BP at systolic targets < 130 mm Hg and the relationship of office BP to ambulatory BP and home BP.

## 1 | OFFICE BLOOD PRESSURE MEASUREMENT IN ROUTINE CLINICAL PRACTICE

Recent guidelines have recommended using ambulatory blood pressure monitoring (ABPM) or home blood pressure (BP) for making a diagnosis of hypertension. However, office BP measurements are still being used by most physicians, even though out-of-office readings are a significantly better predictor of cardiovascular risk. Moreover, the continued reliance on office BP for the screening and management of hypertension assumes that the readings obtained in routine clinical practice are comparable to the BP recorded in research studies in accordance with standardized guidelines. However, a closer examination of the available evidence does not support this assumption.

Based upon data from 7 studies[1] in 4 countries, the mean manual office BP (153/90) mm Hg recorded in routine clinical practice was 10/7 mm Hg higher than the mean manual BP recorded in research studies according to guidelines (143/83 mm Hg). Similarly, routine office BP in 9 studies[1] from 6 countries (156/90 mm Hg) was 17/8 mm Hg higher than the mean awake ambulatory (A)BP (139/82 mm Hg). In another study,[2] involving 27 211 patients in the Spanish ABPM Registry with persistent hypertension despite being on antihypertensive therapy who had their office BP recorded in duplicate using an oscillometric sphygmomanometer, routine office BP was 160/89 mm Hg compared to an awake ABP of 135/78 mm Hg. Thus, using either manual or electronic sphygmomanometers to diagnose hypertension in routine clinical practice will often result in higher BP readings.

Not only is routine manual office BP subject to a "white coat effect" (WCE), but it is also inaccurate, correlating relatively poorly with the awake ambulatory BP.[3-5] Routine manual office BP is also subject to digit preference, with about 50% of readings ending in a zero value.[3-5] Despite numerous educational programs, the quality of BP measurement in everyday clinical practice is not only poor but also results in the systematic overdiagnosis of hypertension.

In order to obtain the most accurate manual office BP, health providers must take into consideration a number of requirements that can

  

affect the readings. Depending on the specific measurement technique, the following aspects will need to be considered: the need for resting before the first reading, the number of readings and interval between readings, the use of an appropriate size cuff, multiple readings if an arrhythmia is present, measurement of BP in both arms at the initial visit and readings both sitting and standing if orthostatic changes in BP are suspected. In some patients, especially those with large, conical shaped arms, BP measurements at the wrist might be preferable. For all patients, the heart rate should also be noted, because it provides additional information about the status of the patient.

## 2 | ALTERNATIVES TO MANUAL BP MEASUREMENT WITH THE MERCURY SPHYGMOMANOMETER

The most readily available alternative to the mercury sphygmomanometer is the aneroid device that has been used in clinical practice for decades. This BP recorder can produce reasonably accurate readings, but it has one important limitation. Its mechanism for measuring BP involves mechanical parts that require recalibration after repeated use. Several studies have reported that regular servicing is frequently not performed in clinical practice, resulting in these devices producing inaccurate readings in a high proportion of patients.

More recently, hybrid sphygmomanometers have been developed that produce accurate BP readings using the manual technique, but with an electronic pressure gauge replacing the mercury column. Some hybrid devices also record BP readings semiautomatically via oscillometry. Examples of hybrid sphygmomanometers include the Accoson Greenlight 300, Heine Gamma G7, Nissei DM-3000, Rossmax Mandaus, and the Welch Allyn Maxi-Stabil 3. When used in the auscultatory mode, hybrid sphygmomanometers require the presence of office staff to measure the BP using a stethoscope to detect the Korotkoff sounds. These requirements, related to the auscultatory method itself, increase the likelihood of a WCE, due either to no antecedent rest, conversation, or office staff in close contact with the patient. There is little information available on the need for recalibration of specific hybrid devices.

## 3 | OSCILLOMETRIC SPHYGMOMANOMETERS FOR OFFICE BLOOD PRESSURE MEASUREMENT BY OFFICE STAFF

In recent years, oscillometric sphygmomanometers originally designed for home BP measurement have been modified for use in the office setting to record and store multiple BP readings following a single activation of the start button. These devices are relatively inexpensive but may lack the durability required for frequent office use. Unlike the oscillometric devices designed for professional use, these automated sphygmomanometers usually cannot be programmed to have their readings preceded by 0-5 minutes of rest. Providing the nurse or doctor is not too close to the patient and there is no opportunity for conversation with the patient, these guidelines-quality, attended office BP measurements may produce results that are similar to readings recorded with the patient being alone. However, more research is needed to determine the feasibility of obtaining this type of BP measurement in routine clinical practice.

It should be noted that some guidelines have recommended periodic recalibration for oscillometric sphygmomanometers. However, not all manufacturers routinely offer this service, which can make it difficult and impractical to adhere to the recommendations. Cost factors may also limit recalibration, especially of home BP devices, which are relatively inexpensive.

## 4 | AUTOMATED OFFICE BLOOD PRESSURE MEASUREMENT

Oscillometric sphygmomanometers specifically designed for professional use in the office have made it possible to obtain 3-5 BP readings automatically, with the patient resting alone in a quiet place.[1] These readings have been called automated office BP (AOBP).

Several independently validated devices have been used to record AOBP in research studies, including the BpTRU,[4] Omron 907XL [6], and WatchBP Office.[7] These devices have their own unique algorithms for determining BP and record 3-5 readings with about 30-60 seconds between readings. An accurate AOBP reading requires 3-7 minutes, which is the same time as a manual or oscillometric BP recorded in duplicate by office staff after 5 minutes of rest. AOBP does not require this additional 5 minutes of rest. Today, most of the major manufacturers of home BP recorders market devices that also may be suitable for unattended office BP measurement.

Several advantages of AOBP have been reported. In comparative studies,[1] the mean BP recorded in routine office practice (151/85 mm Hg) was 16/7 mm Hg higher than the mean AOBP (135/78 mm Hg). AOBP also exhibits significantly less digit preference than routine manual office BP.[3-5] Furthermore, AOBP readings are consistent between visits, even in different locations, with an intraclass coefficient of correlation for systolic/diastolic BP of $r = .896/r = .873$ for readings taken during 3 visits.[8] AOBP can be performed in quiet places other than an examining room, such as in a community pharmacy[9] or a doctor's waiting room.[10]

## 5 | ATTENDED VS UNATTENDED BLOOD PRESSURE MEASUREMENT

Recent publications have questioned whether unattended office BP actually produces lower or more accurate readings than readings taken when office staff are present (attended BP). In a report from the SPRINT investigators,[11] the cardiovascular event rate in the 4082 participants who had a proper unattended AOBP performed was similar to the rate in the 2247 participants who had attended AOBP-type readings taken in the presence of research staff. The relevance

of these findings to the use of AOBP for hypertension treatment target is questionable, because there is no apparent WCE when office systolic BP is less than 125 mm Hg,[12] which was the BP range examined in the comparisons between attended and unattended BP readings in SPRINT. When office systolic BP readings are below the target of 130 mm Hg, the method of recording BP becomes less important, with the possible exception of manual BP in routine clinical practice, for which there are no data. It should also be noted that the attended office BP readings in SPRINT were likely of exceptionally high quality, considering the attention given in the procedure manual to having the patient resting quietly before and during the readings.

Two other studies have also reported similar attended and unattended AOBP-type readings. Al-Kharki and colleagues[13] used a fully automated sphygmomanometer in 162 patients to obtain 3 BP readings at 1 minute intervals after an initial activation, either by the patient while alone or in the presence of research staff who activated the device but otherwise remained silent. Mean attended BP (139/84 mm Hg) was similar to the unattended BP (138/86 mm Hg). More recently, Bauer and colleagues[14] performed AOBP-type readings in 51 patients using an Omron 907 device and found the mean BP similar if attended (136/81 mm Hg) or unattended (134/81 mm Hg). Because the objective of both of these studies was to determine if the patient needed to be alone to obtain an AOBP reading, it is almost certain that BP measurement guidelines, including no conversation, were strictly followed. These findings highlight the need to perform BP measurements according to the standardized rules and do not invalidate the use of AOBP for hypertension screening in routine clinical practice, because there is a long history of routine BP readings being less accurate than guidelines-quality BP in research studies and also associated with a WCE.

## 6 | AOBP AND CARDIOVASCULAR OUTCOMES

There are some data comparing AOBP with manual office BP using target organ damage as the outcome. In 1 study involving 176 healthy participants,[15] the intima-media wall thickness of the carotid artery correlated significantly with systolic/diastolic AOBP ($P = .02/P = .007$) but not with manual BP readings. In another study,[16] involving 90 hypertensive patients, AOBP and awake ambulatory systolic BP readings correlated similarly ($r = .37$) with left ventricular mass index $P < .01$), whereas office BP recorded by research staff using an oscillometric sphygmomanometer showed a relatively poor correlation ($r = .12$).

There are also longitudinal clinical outcome data to support the use of AOBP in clinical practice. The Cardiovascular Health Awareness Program (CHAP), which used AOBP as the method for determining the participants' BP status, is the only study to report a significant decrease in cardiovascular outcomes with BP screening.[17] Additional analyses of fatal and nonfatal cardiovascular events during 4.9 years of follow-up of the CHAP study's participants have been performed in 3267 persons aged > 65 years who were untreated for hypertension at baseline.[18] There was a progressive increase in cardiovascular events starting at a systolic BP of 110/60 mm Hg and becoming statistically significant at a threshold of 135/80 mm Hg. In a parallel study [19] in 6183 treated hypertensive participants in CHAP followed for 4.6 years, the lowest rate of cardiovascular events occurred at an achieved AOBP of 110-119 mm Hg, which is consistent with the benefits of treating to a systolic AOBP target < 120 mm Hg in SPRINT. Finally, SPRINT[6] used the AOBP (or AOBP-like) technique in demonstrating increased benefit for hypertensive patients at a higher cardiovascular risk when treated to a target systolic BP target < 120 mm Hg.

## 7 | IMPLICATIONS OF INTRODUCING AOBP INTO ROUTINE CLINICAL PRACTICE

Based upon the current evidence, AOBP has definite advantages over attended manual BP measurement in clinical practice, especially a reduction in the WCE. AOBP also does not seem to increase the prevalence of masked hypertension.[20] Critics of AOBP have expressed concern about the feasibility of introducing AOBP into clinical practice.[21] However, the inclusion of AOBP into the Canadian hypertension guidelines in 2011 has resulted in AOBP being used in more than 50% of primary care offices by 2016[22] and AOBP is now the preferred method for office BP measurement in Canada.[23] The Canadian experience suggests that replacement of attended office BP for hypertension screening is indeed feasible in places such as the United States and Europe.

## 8 | OFFICE BP MEASUREMENTS AND THE 2017 AMERICAN GUIDELINES

The 2017 comprehensive American hypertension guidelines[24] gave little consideration to newer methods of office BP measurement. Nonetheless, they proposed a new threshold of 130/80 mm Hg for defining hypertension, based upon the office BP. Minimal evidence was provided for a guidelines-quality manual office BP being equivalent to an awake ABP at 130/80 mm Hg and there are no data for manual office BP vs the awake ABP at this level in routine clinical practice.

However, data for a diagnostic threshold at 130/80 mm Hg using electronic sphygmomanometers in primary care are available from the Spanish ABPM Registry.[2] In 5028 patients, a mean attended oscillometric office BP of 131.5/81.0 was higher than the corresponding mean awake ABP of 125.9/75.6 mm Hg. Thus, simply replacing a manual recorder with an oscillometric sphygmomanometer in the office may not make the office BP and awake ABP equivalent outside of the research setting. In contrast, studies in patients with a systolic office AOBP in the 130-133 range have reported only a small difference of 1-2 mm Hg compared to the awake ABP, which is important because AOBP readings, unlike conventional office BP, are similar in different settings.[1] It is important to note that the relationship between all techniques for the measurement of office BP vs awake ABP changes below a systolic BP of 130 mm Hg, with the office BP

becoming less than the awake ambulatory BP, when the office systolic BP is in the low 120s.[12]

## 9 | CONCLUSIONS

Considering the long history of office staff not following the rules of manual BP measurements and the increased use of electronic sphygmomanometers in clinical practice, there does not seem to be any added benefit to having doctors or nurses present when BP readings are being recorded. Most of the research to date has used automated sphygmomanometers designed for professional use. However, unattended office BP using home BP recorders modified for office practice would seem preferable to conventional (attended) office BP measurement when screening for hypertension in clinical practice. Other methods for recording office BP may also be useful in special situations, provided that standard guidelines for BP measurement are followed.

### CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. No sources of funding to declare.

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