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REVIEW PAPER

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Office blood pressure measurement: A comprehensive review

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Abstract

The conventional auscultatory methods for measuring blood pressure have been used to screen, diagnose, and manage hypertension since long. However, these have been found to be prone to errors especially the white coat phenomena which cause falsely high blood pressure readings. The Mercury sphygmomanometer and the Aneroid variety are no longer recommended by WHO for varying reasons. The Oscillometric devices are now recommended with preference for the Automated Office Blood Pressure measurement device which was found to have readings nearest to the Awake Ambulatory Blood Pressure readings. The downside for this device is the cost barrier. The alternative is to use the simple oscillometric device, which is much cheaper, with the rest and isolation criteria of the SPRINT study. This too may be difficult due to space constraints and the post-clinic blood measurement is a new concept worth further exploration.

1 | INTRODUCTION

In 2015, the global prevalence of hypertension was estimated to be more than 1.1 billion.[1] The highest prevalence of raised blood pressure (BP) among people aged ≥18 years was in low-income countries (28.4%) and middle-income countries (25.5%). In 2017, the Global Burden of Disease study found that raised systolic blood pressure (SBP) was the leading modifiable risk factor for death globally, with 10.4 million deaths annually attributed to this cause.[2]

The diagnosis of hypertension has classically been made by office/clinic BP measurements. This has evolved over time from Mercury sphygmomanometers to Aneroid, Hybrid (quasi-mercury) and then Oscillometric devices.[3,4] However, there have been multiple problems in obtaining correct BP readings in the office. These include *observer errors* caused by lack of concentration, poor hearing, confusion of auditory, and visual cues, etc. The most important factor is failure to interpret the Korotkoff sounds accurately, especially for diastolic blood pressure (DBP). Terminal digit preference and observer bias are also causes of inaccurate measurements.[5]

Device problems are also common. In a study of 210 mercury and aneroid sphygmomanometer, nearly half had some fault.[6] *Methodology errors*, which are mostly due to inadequate attention to the recommended guidelines, are a major cause of inaccuracy of BP measurement. BP is rarely measured in accordance with the strict guidelines in a screening or clinical setting, and the accuracy of measurement is often disregarded or ignored.[7] In a study of 150 patients, BP measured by usual care was compared with that measured strictly following the American Heart Association guidelines. There was a mean lowering of about 12/6 mmHg when the guidelines were followed.[8]

Another major problem with office blood pressure (OBP) measurements is the alerting response which causes the white coat phenomena seen as white coat hypertension in non-hypertensives and white coat effect in known hypertensives.[3,4,7,9] The pressor and tachycardiac responses to the alerting reaction that accompanies sphygmomanometric blood pressure measurement is characterized by a behavior of the adrenergic nervous system that causes muscle sympathoinhibition and skin sympathoexcitation.[10] In a study by Dolan et al, the overall prevalence of white coat hypertension was 15.4% and a higher prevalence was seen among older adults, females, and non-smokers.[11] This is seen more often when doctors measure the BP and less so with nurses.[12,13] It is not due to device error as the oscillometric home blood pressure measurement (HBPM) gives lower BP readings at home but the same device when used in a clinical setting in the Spanish ABPM registry gave markedly higher BP readings.[14]

The inability to diagnose masked hypertension is another drawback of OBP as by definition, masked hypertension in untreated hypertensive patients or masked uncontrolled hypertension (MUCH) in treated hypertensive patients is controlled BP in clinic as measured by OBP but uncontrolled BP out-of-clinic as measured by 24-h ambulatory BP monitoring (ABPM) or by HBPM.[15] The prevalence in the population is reported as 10%–26% (mean 13%).[4] This is reported to be more common in smokers, hypertensives on treatment, males, elderly, alcohol consumers, African Americans, diabetics, and chronic kidney disease. In the study by Siddiqui et al, it was found that patients with MUCH had evidence of heightened out-of-clinic sympathetic activity compared with true controlled hypertensive patients.[15]

Problems with OBP measurements have led to the development of various devices and methodologies that have proven to give more accurate BP measurements. This includes the HBPM device which is used by the patient at home over a period of days or weeks and the ABPM device which is usually applied for 24 h and is preprogrammed to take measurements at set intervals. The ABPM is now regarded as the best technology for BP measurement[3,4,16,17] followed by HBPM[16,18] as both these methods can diagnose masked hypertension and avoid the pitfall of white coat hypertension in addition to other benefits.

This review is limited to the device types and methodologies used for BP measurement in the office/clinic only and will not discuss HBPM or ABPM. The methodologies employed during measurement including the device types, individual measuring or unattended measurements, prior rest period, and timing of measurements will be discussed. The standardized BP measurement techniques as mentioned in the various hypertension guidelines must be followed regardless of the methodology employed.[3,4,7,16,19] It is also clarified that the words *office* and *clinic* are used interchangeably in this review.

2 | DEVICE TYPES

2.1 | Auscultatory devices

The first group are the auscultatory devices where a trained observer uses a stethoscope to listen to the Korotkoff sounds and makes a determination as to the SBP and DBP. Thus, these are all prone to the observer errors mentioned above and also to the white coat phenomenon as unattended readings are not possible.

2.1.1 | Mercury sphygmomanometer

This has been the classical way of measurement and has been regarded as the gold standard. The validity of newer devices is checked against this device. It is inexpensive, requires limited maintenance, and requires no energy source. It is still being used by a large number of doctors worldwide. In a study of 774 family physicians in Canada published in 2017, 54.2% were still using the auscultatory methods (which include both mercury and aneroid sphygmomanometers) for screening, 21.4% for diagnosis, and 63.6% for follow-up of hypertension.[20] A study of 445 primary care doctors in Hong Kong published this year revealed that the auscultatory methods were being used by 63.1% for screening, 56.4% for diagnosis, and 72.4% for follow-up.[21] In an unpublished study done in Pakistan by Bilal M. and Siddique S., in 500 doctors

(over 2/3rds of these working as junior hospital doctors in the field of cardiology), 61% were using mercury sphygmomanometer and 24% the aneroid variety (*personal communication*). The problems with this instrument are the use of a toxic material, that is, mercury, which is being phased out following the Minamata Convention.[22] It is no longer recommended by the World Health Organization (WHO) due to the toxic material and should be phased out (WHO Technical Specifications for Automated non-invasive BP measuring devices with cuff, p. 6).[23]

2.1.2 | Aneroid sphygmomanometer

This device has the advantage of being easy to carry around and use, is inexpensive, and needs no energy source. However, it is prone to inaccuracy in case of mishandling, for example, physical shocks, and needs to be calibrated at fixed intervals (at least every 6 months).[23] Unlike the mercury device in which the mercury level can be checked visually, there is no way for the individual performing the test to be sure of the accuracy of this device. This device is also no longer recommended by WHO because of the requirement for frequent recalibration and observer training and retraining (WHO Technical Specifications for Automated non-invasive BP measuring devices with cuff, p. 6).[23]

2.1.3 | Hybrid (quasi-mercury)

An electronically generated pressure column (quasi-mercury) sphygmomanometer is a sphygmomanometer using an electronic analog column instead of a mercury column.[3,4,7] With a hybrid sphygmomanometer, a liquid crystal display column or light-emitting diode screen moves smoothly like a mercury column or aneroid-like display. It is an auscultatory method and is, therefore, prone to the observer errors common to this method including the white coat phenomenon.

2.1.4 | Automated auscultatory

This is an electronic BP measuring device which uses high sensitivity microphones to detect the Korotokoff sounds. Thus, the human ear is not required and measurements can be fully automated which eliminates the white coat effect seen with other auscultatory devices. However, the area of automated BP measurement has been virtually taken over by the automated oscillometric technique (discussed below) and this device is not specifically mentioned in any of the major hypertension guidelines.[3,4,7,16,19] However, some of these do mention validated devices. The dable Educational Trust web site makes up-to-date evidence-based information available regarding BP devices and lists the BP devices validated under international protocols.[24] Under its latest listing of recommended Automated Devices for Clinical Use, there are over a 100 different devices, the vast majority being oscillometric. Only 4 recommended devices have auscultatory component. It is therefore a validated methodology and as many countries/regions have separate accreditation lists for BP devices, it is possible that in certain countries, it may be more prevalent.

2.2 | Oscillometric devices

These are of two types:

The simple type designed for home blood pressure monitoring which is also being used in many office practices. The one with the upper arm cuff is recommended and not the wrist or finger varieties as the latter have not been clinically validated.[23] This device has to be activated by an individual, either a professional, that is, doctor or nurse etc or by the patient. There are reports of having white coat phenomena by this process.[3,4,16] In 27 211 patients with hypertension in the Spanish ABPM Registry, the mean oscillometric OBP was 160/89 mmHg, compared with a mean awake ambulatory blood pressure (ABP) of 135/78 mmHg.[14] Thus, simply replacing manual BP with an oscillometric device did not eliminate the white coat effect if other parameters like rest, isolation, and unattended BP measurement were not followed.

The professional type, again with the upper arm cuff. This has an inbuilt delay before starting the measurement and can be programmed to do repeated measurements (at least three) with a time delay between measurements. This is called the automated office blood pressure measurement (AOBP).[25] This is the method that was employed in the SPRINT study comprising 9316 patients in which the SBP by AOBP was found to be similar to SBP of 24 h ABP and about 7 mm less than daytime ambulatory SBP.[26] In a meta-analysis to examine the association between AOBP and OBP readings (manual or oscillometric) measured in routine clinical practice and in research studies, and awake ABP, it was found that in samples with systolic AOBP of 130 mmHg or more, routine office and research SBP readings were substantially higher than AOBP readings, with a pooled mean difference of 14.5 mmHg (95% CI, 11.8–17.2 mmHg; $n = 9$; $I^2 = 94.3\%$; $p < .001$) for routine office SBP readings and 7.0 mmHg (95% CI, 4.9–9.1 mmHg; $n = 9$; $I^2 = 85.7\%$; $p < .001$) for research SBP readings. There was no significant difference in SBP readings between awake ABP and AOBP, with a pooled mean difference of 0.3 mmHg (95% CI, −1.1 to 1.7 mmHg; $n = 19$; $I^2 = 90\%$; $p < .001$).[25] The authors concluded that AOBP should now be the preferred method for recording BP in routine clinical practice.

There are question marks over the prognostic significance of the AOBP measurements.[3] However, in a study by Campbell et al in 176 patients, the AOBP readings correlated better with carotid intima-media thickness than the auscultatory BP.[27] Another study by Andreadis et al concluded that high-quality AOBP readings and ABP measurements correlate equally well with left ventricular mass indices.[28]

2.3 | New innovations

There are many new innovations in the market which are cuff-less and calculate the BP from various other parameters including Pulse transit time, Ultrasound or Magnetic method, Tissue characteristic methods, Machine-learning methods, Heart-rate variation and heart-rate power spectrum ratio, Photoplethysmography, Heart rate, and smartphone technology. None of these technologies have been validated, they are not regulated, and there is no unified, standard system to evaluate their accuracy, performance, or use. Thus, these emerging technologies cannot yet be recommended for clinical use (WHO Technical Specifications for Automated non-invasive BP measuring devices with cuff, pp.30–31).[23]

3 | METHODOLOGIES

3.1 | Individual performing the test

3.1.1 | Doctors

BP readings taken by doctors have been shown to be the most unreliable as the worst form of white coat phenomena manifest when doctors perform the measurement.[12]

3.1.2 | Nurses

It has been uniformly seen in multiple trials that nurses' BP readings are less than the ones taken by doctors.[12] However, the white coat phenomenon is not totally nullified and is still seen in these readings.[13]

3.1.3 | Automated readings

These could be attended or unattended.

Fully automated unattended readings have been shown to be the lowest and most compatible with daytime ABPM readings.[29] However, in a study by Julia Holler et al,[30] in 42 consecutive patients with hypertension, attended AOBP was 131.7/83.4 mmHg compared with unattended AOBP of 131.6/82.4 mmHg. This was contrary to the results of a trial by Berkhof et al.[31] Their study consisted of 120 patients who performed three self-initiated and three fully automated BP measurements. In this cohort (mean age 58.0 ± 14.1 years, mean OBP 153.6 ± 23.8/86.3 ± 14.0 mmHg, 44.1% female), self-initiated BP measurement resulted in a 2.1 ± 6.8/0.9 ± 4.0 mmHg higher systolic and diastolic blood pressure (DBP) compared with fully automated self-measurement (p = .001/.018). Thus, there was a small but significant reduction of both SBP and DBP when the fully automated device was used. In another study by Bauer et al,[32] unattended to attended AOBP were compared in 51 patients. Unattended BP was calculated as the mean of 3 automated measurements performed in a separate room after 5 min of rest.

Unattended and attended AOBP were 134.2/80.6 and 135.7/80.6 mmHg. Their conclusion was that unattended and attended office BP measurements achieve comparable results, if measurements take place at a familiar general practitioner's office. In an editorial by Stergio et al, six studies are mentioned which consistently showed that when several OBP measurements are taken using automated devices without talking to the patient, the presence of the observer has little or no effect on measured OBP (95% CIs in all studies excluded any clinically important difference).[33] Moreover, in a study by Salvetti et al, it was shown that both left ventricular mass index and carotid intima-media thickness were similarly correlated with attended and unattended systolic BP.[34]

Another advantage of AOBP shown in trials is that it is fairly constant no matter where it is performed. In a study by Chambers et al,[35] AOBP measurements were obtained in family physicians' offices and were compared with those obtained in community pharmacies in 275 patients aged 65 years or older. The mean difference between the measurements at the two locations was <1.1/0.5 mmHg. Their conclusion was that measurements of blood pressure using an automated device in a pharmacy can provide accurate and valid blood pressure information that can be used in the diagnosis and management of hypertension among older adults in the community. In another study by Armstrong et al,[36] AOBP readings using the BpTRU device recorded with the patient resting quietly in the waiting room were obtained in patients referred for ABPM and the relationship between the AOBP and awake ABP (mmHg) was examined. In 422 patients, the mean (±SD) awake ABP (139.4 ± 13.4/80.7 ± 10.6) was similar to the mean AOBP recorded in the waiting room (140.5 ± 19.8/83.1 ± 11.2), with both values being significantly lower than a single office BP (155.1 ± 18.7/90.2 ± 12.7) taken by a nurse. They concluded that AOBP readings recorded in a waiting room are comparable with the awake ABP, making it possible to obtain AOBP in clinical practice without the need to occupy an examining room.

3.2 | Prior rest period and timing of BP readings

3.2.1 | Prior rest period

This has been recommended as part of the standardized technique for all BP measurements.[3,4,7,16,19] However, the quality of this rest period has been redefined lately and is now taken as rest in an isolated room with no talking or interaction with anyone.[26]

3.2.2 | Timing of BP measurements

These can be pre-clinic, in-clinic, or post-clinic.

BP has often been take pre-clinic, usually by a nurse or trained assistant, and this is usually found to be less than the in-clinic BP measured by the doctor.[12,13]

The post-clinic BP is an interesting concept which has not been extensively investigated. In a study from Aga Khan University Hospital in Karachi, Pakistan,[37] the pre-clinic reading was taken by the assessment nurse after the patients waited for 16 ± 1.7 min before being seen. The in-clinic reading was taken by the physician inside the clinic room after 15 ± 2.1 min wait. After the clinic encounter was over, participants were asked to be seated, with a prohibition of smoking or exertion but not of talking or interaction with others, for another 15 min in the waiting area. An interval of 15 min was chosen to match the time interval that the patients waited before pre-clinic and in-clinic readings were taken. After 15 ± 1.3 min, participants were called back to another clinic room where post-clinic readings were taken. The two post-clinic readings were taken by a research officer at an interval of 1 min. A standard BP measurement protocol was observed for all four BP readings. BP was measured in the right arm at heart level, while participants were seated in a chair with a back-rest. They were asked not to talk during the time the readings were taken. All BP readings were taken using an automated and validated Omron HEM7221-E to avoid inter-observer variability. Mean SBP taken pre-clinic, in-clinic, post-clinic 1, and post-clinic 2 were 126 ± 20 mmHg, 131 ± 23 mmHg, 126 ± 20 mmHg and 121 ± 21 mmHg, respectively ($p < .001$). Mean DBP taken pre-clinic, in-clinic, post-clinic 1, and post-clinic 2 were 77 ± 12 mmHg, 81 ± 13 mmHg, 79 ± 12 mmHg, and 79 ± 11 mmHg, respectively ($p < .001$). The post-clinic 2 SBP and DBP were 10 mmHg and 2 mmHg lower than the in-clinic SBP and DBP, respectively.[37]

The same group then repeated the study, this time comparing with ABP also.[38] After the post-clinic BP reading was taken, a 24 h ABPM monitor (SpaceLabs, model: 90217A) was attached to each participant which took BP and pulse readings every half hour during the daytime and every hour during nighttime. Among the three readings taken during a clinic visit, mean (±SD) SBP pre-clinic, in-clinic, and 15 min post-clinic were 153.2 ± 23, 152.3 ± 21, and 140.0 ± 18 mmHg, respectively. Mean (±SD) DBP taken pre-clinic, in-clinic, and 15 min post-clinic were 83.5 ± 12, 90.9 ± 12, and 86.4 ± 11 mmHg, respectively. Mean (±SD) daytime ambulatory SBP, DBP, and pulse readings were 134.7 ± 15, 78.7 ± 15 mmHg, and 72.6 ± 12/min, respectively. This study replicated the findings of their previous study and the post-clinic SBP correlated better with the daytime systolic ABP reading than the pre-clinic or in-clinic readings. The authors stated that their results were comparable to Mancia et al's study[39] which showed that patients' BP and heart rate increased when visited by a physician or a nurse, the rise being higher with the physician. Both heart rate and BP then declined, over the next 10 min, by about 10/5 mmHg owing to the reduction in the alert reaction. Another study showed that serial automated office SBP readings taken in a quiet room using the ABPM device decreased by about 12 mmHg to reach a plateau over 15 min and these readings remained similar at 30 min.[40] They concluded that post-clinic BP can be more reliable than the conventional methods as well as being more cost-effective upfront in comparison with ABPM for assessment of hypertension and adjusting medications but further studies with a larger sample size are required to determine the prognostic value of post-clinic BP and its association with cardiovascular outcomes.[38]

4 | PROBLEMS WITH AOBP

It can be seen from the above that AOBP has the best correlation with daytime ABP readings. However, as with all other devices, it too has its share of problems.

4.1 | Cost and durability

The upfront cost is 500–900 US dollars (as found on Internet search), and there would be additional costs for training and regular maintenance. This is a fairly large figure compared with validated simpler oscillometric devices which are about 1/10th the price (this estimation will vary in different countries depending on taxation, pricing methodology, availability etc). To make provision for this device for even 50% of the practicing doctors in a country would involve a considerable outlay. Then, there is also the question of durability which is not clearly defined but these devices will have to be replaced at variable intervals.

4.2 | Validation

This is an essential requirement mentioned in the above guidelines and needs to be done according to the Universal Validation Standards (WHO Technical Specifications for Automated non-invasive BP measuring devices with cuff, table 3).[23] This involves extra effort on the part of the manufacturers and regulators, and the users have to be aware of the validated lists of models.

4.3 | Separate room

This may not be a problem for the resource rich countries but is a major obstacle in resource poor countries, both in a busy hospital outpatient department and in family practices. However, at least one study has shown that AOBP readings in a patient resting quietly in a waiting room (and not alone in a separate room) were comparable to the awake ABP measurements.[36]

4.4 | Accuracy and maintenance

The frequency of accuracy checks must be in accordance with manufacturer's recommendations, which depends on the type of technology. The usual interval is once every 1 or 2 years. Nevertheless, experience indicates that, if an oscillometric device is used frequently every day in clinical practice, the integrity of the cuff and tubing and the adequacy of the power source should be checked at

TABLE 1 Comparison of BP measurement methodology in various guidelines

Item	AHA 2017	ESC 2018	CHEP 2020	JSH 2019	Chinese HTN 2018
Device type	Mercury, Aneroid, Hybrid quasi-mercury, AOBP	Auscultatory or Oscillometric semi-automated, Hybrid quasi-mercury, AOBP	AOBP Oscillometric Aneroid Mercury	Mercury Aneroid Electronic -quasi mercury	Oscillometric Mercury AOBP
Position	Sitting, back supported, feet flat on the floor	Sitting, back supported	Sitting, back supported, legs uncrossed	Sitting, back supported, legs uncrossed	Sitting
Rest period	>5 min	>5 min	>5 min	Few mins	>5 min
Avoid	Caffeine, exercise, Smoking	-	-	Smoking, Caffeine, Alcohol	-
Empty urinary bladder	Yes	-	-	-	-
No talking	Yes	-	Yes	Yes	-
Bare arm	Yes	-	Yes	-	-
Cuff position	Upper arm	Upper arm	Upper arm	Upper arm	Upper arm
Cuff size	Appropriate sized	Appropriate sized	Appropriate sized	Appropriate sized	Appropriate sized
Deflation	2 mm/s	-	2 mm/beat	2–3 mm/beat or second	2 mm/s
Korotkoff SBP	I	I	I	I	I
Korotkoff DBP[a]	V	V	V	V	V
No. of readings	≥2	3	3	≥2	2
Average of;	All readings	All readings	Last 2 readings	All readings	All readings
Interval between readings	1–2 min	1–2 min	>1 min	1–2 min	1–2 min
Record heart rate	-	Yes	Yes	Yes	Yes
BP in both arms	First visit	First visit	One visit	First visit	First visit
Standing BP	-	All at first visit	All at first visit	Diabetics, elderly	Diabetics, elderly, if fall suspected
Time for standing BP measurement	-	At 1 and 3 min	At 2 min	-	-

Abbreviations: AHA, American Heart Association[4]; CHEP, Canadian Hypertension Education Program Supplemental Table 1[16]; Chinese HTN, Chinese Hypertension Guidelines[19]; ESC, European Society of Cardiology[3]; JSH, Japanese Society of Hypertension.[7]

[a]Korotkoff IV is recommended for specific conditions.

least once a month by users or clinical engineers (WHO Technical Specifications for Automated non-invasive BP measuring devices with cuff, p. 14).[23]

4.5 | Arrhythmias

Standard AOBP device still has problems with accurate measurement of BP in patients with arrhythmias, for example, atrial fibrillation.[41] In the case of arrhythmia, additional readings by auscultation may be required to estimate the average systolic and diastolic pressure.[16]

4.6 | Masked hypertension

As masked hypertension patients by definition have normal OBP measurements, lowering of the office BP by AOBP may increase the prevalence of such patients. In a sub-study of the CAMBO trial,[42] ABP, AOBP, and conventional manual office BP were checked. The prevalence for masked hypertension based upon both SBP and DBP was similar being 11%–15% for AOBP and 19%–20% for manual BP patients on single visits, but decreased to 6% and 10% when readings from the first two visits were used and to 4% and 6% when all three visits were used for the AOBP and manual BP groups, respectively. The authors concluded that the prevalence of masked hypertension is lower with AOBP compared with manual BP and the number of patients with masked hypertension decreases if the criteria for having this condition need to be met on multiple visits.

4.7 | Clinical implications on patient-doctor relationship

The use of AOBP may have some impact on developing this relationship. However, this rapport is built by the doctor being present and measuring the BP himself/herself, often while carrying on a conversation with the patient. It has been seen that these are the very actions which are the main reasons of white coat phenomenon and falsely high OBP.[39]

5 | WHAT DO THE GUIDELINES SAY

Table 1 compares select international guidelines regarding OBP. The recommendations are mostly similar with some being more detailed than others. The differences are minor and mostly insignificant. The rest period in the Japanese guidelines is mentioned as a 'few minutes' which is rather non-specific while the others all define it as >5 min. The deflation rate is mentioned as 2 mm/s in the American and Chinese guidelines and 2 mm/beat in the Canadian guidelines while the Japanese guidelines recommends 2–3 mm/beat or second. The recommended number of readings per visit varies from 2–3, with the Canadian guidelines the only one eliminating the first reading, and averaging is recommended by all. The major difference is perhaps in the recommendations for standing BP, both for whom it is necessary and the timing of its measurement.

The recommendations for devices in these guidelines are as follows;

5.1 | ESC/ESH 2018 guidelines

"Auscultatory or oscillometric semiautomatic or automatic sphygmomanometers are the preferred method for measuring BP in the doctor's office. These devices should be validated according to standardized conditions and protocols."

> Presently, the relationship between BP readings obtained with conventional office BP measurement and unattended office BP measurement remains unclear, but available evidence suggests that conventional office SBP readings may be at least 5–15 mmHg higher than SBP levels obtained by unattended office BP measurements. There is also very limited evidence on the prognostic value of unattended office BP measurements, i.e. whether they guarantee at least the same ability to predict outcomes as conventional office BP measurements.[3]

Thus, the ESC/ESH guidelines recommend both auscultatory and oscillometric devices with the proviso that all devices should be validated and but with no preference for one over the other. AOBP is mentioned but with lack of clarity about its prognostic value.

5.2 | ACC/AHA 2017 Guidelines

> The clinical standard of auscultatory measures calibrated to a column of mercury has given way to oscillometric devices.
>
> …only devices with validated measurement protocol can be recommended for use.
>
> Although much of the available BP-related risk information and antihypertensive treatment trial experience have been generated by using "traditional" office methods of BP measurement, there is a growing evidence base supporting the use of automated office BP measurements.[4]

The ACC/AHA guidelines thus prefer validated oscillometric devices with a bias toward AOBP.

5.3 | Hypertension Canada's 2020 guidelines

> Use of standardized measurement techniques and independently validated equipment for all methods (automated OBPM (AOBP), OBPM, ABPM, and HBPM) is recommended. Unless specified otherwise, measurement using electronic (oscillometric) upper arm devices is preferred over auscultation.
>
> AOBP is the preferred method of performing OBPM.[16]

Thus, the Canadian Hypertension guidelines generally allow only oscillometric devices with AOBP being the preferred method for OBPM for both screening and management. It further specifies that diagnosis should be based on ABPM or HBPM and not on OBPM.

5.4 | Japanese hypertension guidelines 2019

> Office blood pressure is measured by the auscultation method, which is the standard procedure, but the use of an automatic sphygmomanometer of the upper arm type is also permitted.[7]

The first choice for OBP, therefore, remains the auscultatory method although it is mentioned that mercury sphygmomanometers will be banned from January 1, 2021.

5.5 | Chinese hypertension guidelines 2018

> Upper arm medical electronic sphygmomanometer, which has been validated by international standardized protocols (ESH, BHS and AAMI), or mercury sphygmomanometer, which is up to the metrological standard (will be deprecated gradually), are used for the measurement. Automated office BP measurement (AOBP) can reduce the white coat effect, which is worthy of further research and promotion.[19]

The emphasis here is on the oscillometric device while the mercury sphygmomanometer is still allowed and the AOBP is mentioned but more for research.

6 | SPECIFIC ASIAN ISSUES

Asia is a very diverse continent in terms of resources, both economically and for human resource. Even within a single country, there are areas, mostly urban, which are rich but have expensive human resource while there are other areas, usually rural, which are poor with abundant human resource and inadequate technical back up. AOBP may be the ideal choice for the former while the simple oscillometric device may be better for the latter. Although most countries have signed the Minamata declaration, some of the under developed ones have not got it ratified from their respective parliaments and are not implementing it. These countries continue to use the mercury sphygmomanometer despite its multiple problems as stated above. In general, clinics and hospitals with adequate financial resources and access to technical back up would be better served by AOBP while those lacking these can choose the simple oscillometric device.

7 | CONCLUSION

Conventional OBP methods of auscultatory mercury or aneroid devices are both not recommended by WHO, the former due to mercury toxicity and the latter due to frequent need for recalibration. Also, both these methods need well trained personnel and are prone to white coat phenomena as these cannot be unattended. Oscillometric devices are recommended with the unattended, fully automated, AOBP giving the best results. However, due to the enhanced cost and area requirements it cannot be recommended as the primary method in resource poor countries at present. Moreover, general usage of this device would impact the BP levels for both diagnosis and treatment as there is a 5–15 mmHg reduction in SBP levels with AOBP compared with conventional methods as mentioned in the ESC guidelines above. This point would need another review.

The alternative would be the self-initiated oscillometric device, duplicating the rest and isolation protocol used in SPRINT if possible. This too may be difficult due to area constraints in busy outpatient departments of hospitals and family practices. In which case, the post-clinic method may be useful in obtaining a reading closer to daytime ABP reading. However, this method needs more validation with further studies in different population groups. Finally, it may be mentioned that with the rapid development in cuff-less technologies, all this may be obsolete in the not too distant future and we may all be measuring our BP on mobile phones.

CONFLICT OF INTEREST

S Siddique has received honoraria from Bayer, Novartis, Pfizer, ICI, and Servier; and travel, accommodation, and conference registration support from Hilton Pharma, Atco Pharmaceutical, Highnoon Laboratories, Horizon Pharma, and ICI. CH Chen reports personal fees from Novartis, Sanofi, Daiichi Sankyo, SERVIER, and Boehringer Ingelheim Pharmaceuticals, Inc. HM Cheng received speakers honorarium and sponsorship to attend conferences and CME seminars from Eli Lilly and AstraZeneca; Pfizer Inc.; Bayer AG; Boehringer Ingelheim Pharmaceuticals, Inc.; Daiichi Sankyo, Novartis Pharmaceuticals, Inc.; SERVIER; Co., Pharmaceuticals Corporation; Sanofi; TAKEDA Pharmaceuticals International and served as an advisor or consultant for ApoDx Technology, Inc. TD Wang has received honoraria from Abbott, AstraZeneca, Boehringer Ingelheim, Daiichi Sankyo, Eli Lilly, Medtronic, Menarini, Novartis, Omron, Pfizer, Sanofi, and Servier. YC Chia has received honorarium and sponsorship at attend conferences and seminars from

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AUTHORS CONTRIBUTION

Siddique S takes primary responsibility for this paper. Siddique S, Khan AH, and Shahab H wrote the manuscript. Khan AH, Shahab H, Zhang YQ, Tay JC, Buranakitjaroen P, Turana Y, Verma N, Chen CH, Cheng HM, Wang TD, Minh HV, Chia YC, and Kario K reviewed/edited the manuscript.

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