

Guidance on ambulatory blood pressure monitoring: A statement from the HOPE Asia Network

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Funding Information

Pfizer.

Abstract

Hypertension is an important public health issue due to its association with a number of serious diseases, including cardiovascular disease and stroke. The importance of evaluating hypertension taking into account different blood pressure (BP) profiles and BP variability (BPV) is increasingly being recognized, and is particularly relevant in Asian populations given the specific features of hypertension in the region (including greater salt sensitivity and a high rate of nocturnal hypertension). Ambulatory BP monitoring (ABPM) is the gold standard for diagnosing hypertension and assessing 24-hour BP and provides data on several important parameters that cannot be obtained using any other form of BP measurement. In addition, ABPM parameters provide better information on cardio- and cerebrovascular risk than office BP. ABPM should be used in all patients with elevated BP, particularly those with unstable office or home BP, or who are suspected to have white-coat or masked hypertension. ABPM is also an important part of hypertension diagnosis and monitoring in high-risk patients. ABPM needs to be performed using a validated device and good practice techniques, and has a role both in hypertension diagnosis and in monitoring the response to antihypertensive therapy to ensure strict BP control throughout the 24-hour period. Use of ABPM in clinical practice may be limited by cost and accessibility, and practical education of physicians and patients is essential. The ABPM evidence and practice points in this document are based on the Hypertension Cardiovascular Outcome Prevention and Evidence (HOPE) Asia Network expert panel consensus recommendations for ABPM in Asia.

1 | INTRODUCTION

Hypertension is an important risk factor for serious diseases, including cardiovascular disease and stroke, making it an important public health issue.^{1,2} Ethnic differences in the pathogenesis and cardiovascular complications of hypertension,³⁻¹⁴ and the rapidly aging population demographic in the region mean that hypertension is a particularly relevant problem in Asia.^{6,15} As a result, it is important to use the latest tools and techniques to diagnose and manage hypertension.

Out-of-office blood pressure (BP) monitoring is highlighted by several major international guidelines as playing a central role in hypertension diagnosis and management.¹⁶⁻²⁴ Out-of-office techniques include home blood pressure monitoring (HBPM) and ambulatory blood pressure monitoring (ABPM). ABPM is considered the state-of-the-art technology for BP measurement, and its use is endorsed by major international guidelines for North America,^{23,25,26} Europe,^{17,19,24} Korea,²⁷ Japan,²² China,²⁸ and Taiwan.¹⁶

Asia-specific evidence and guidance for the use of HBPM are now available.²⁹⁻³¹ In addition, comprehensive consensus-based expert panel recommendations on ABPM from the Hypertension, brain, cardiovascular and renal Outcome Prevention and Evidence in Asia (HOPE Asia) Network have recently been published.³² This practice-focused document provides key messages from the expert panel recommendations and presents a set of ABPM practice points (Figure 1) that can be easily implemented in clinical settings.

2 | ABPM PARAMETERS AND PHENOTYPES

BP reflects the hemodynamic state and is not a static phenomenon. As a result, there are both short-term and long-term variations in BP, referred to as blood pressure variability (BPV). Factors contributing to BPV include genetics, mechanical forces generated during ventilation,

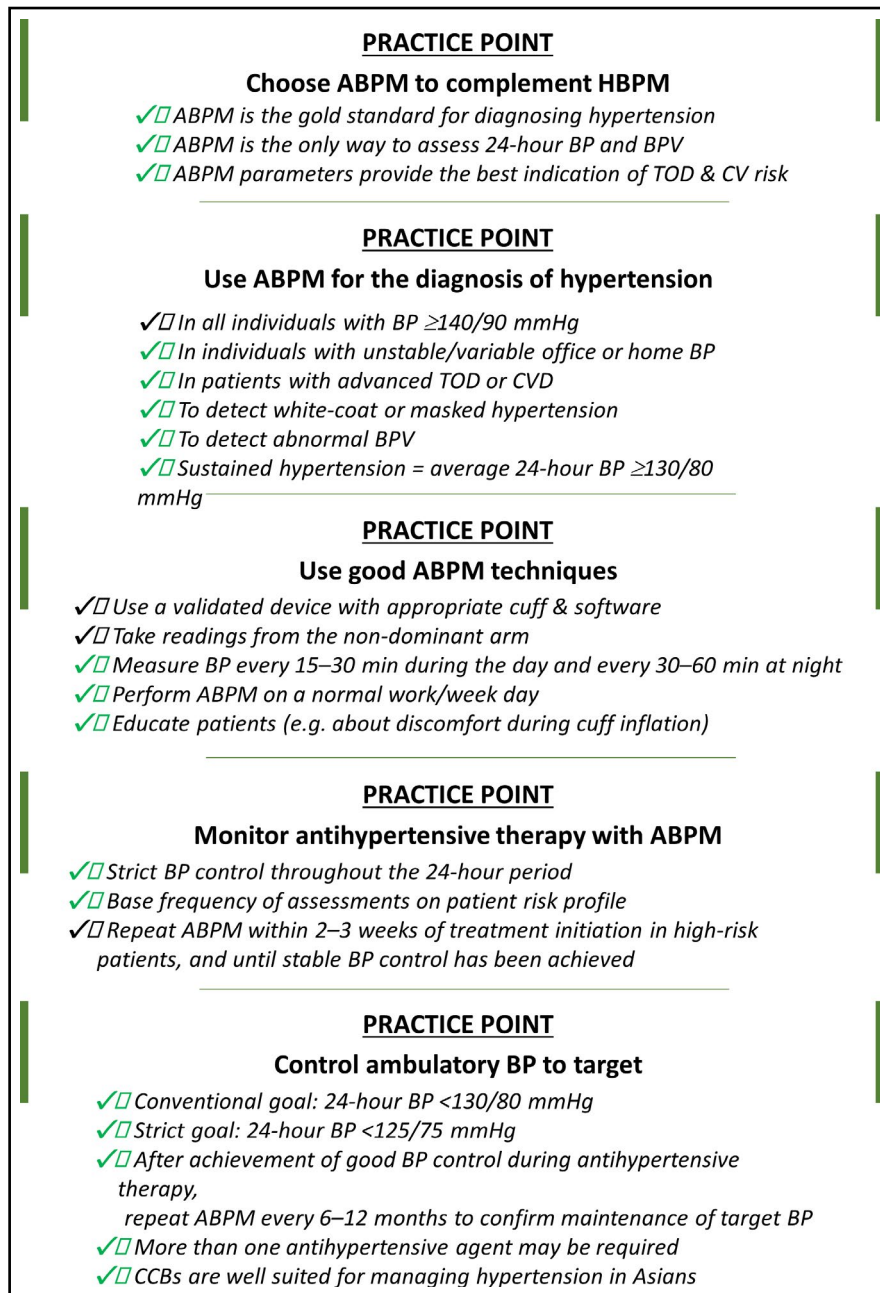


FIGURE 1 Ambulatory blood pressure monitoring (ABPM) practice points. BP, blood pressure; BPV, blood pressure variability; CCBs, calcium channel blockers; CV, cardiovascular; CVD, cardiovascular disease; TOD, target organ damage

local vasomotor phenomena, sympathetic nervous system activity, electrolytes, neurohumoral factors, physical activity, arterial wall thickness, baroreflex mechanisms, time of day, seasonal influences, and possibly also environmental factors.³³ The importance of different BP profiles and BPV is increasingly being recognized. ABPM is one of the tools that facilitate determination of these profiles and variability, allowing patients to be classified into different BP phenotype groups. The clock-based definition of daytime, nighttime, and the morning was from awakening to going to bed, from going to bed to awaking, and the 2 hours after awaking, respectively (Figure 2).

BP is usually higher during the day (or periods of wakefulness) and lower at night (or periods of sleep). The expected physiological

fall in nighttime BP is $> 10\%$ (dipping), whereas a reduction of $< 10\%$ in BP at night is defined as non-dipping; patients with a riser (or reverse dipping) pattern show an increase in BP during sleeping hours to levels (BP fall is $< 0\%$) that may be higher than those during the day (ie, nocturnal hypertension).³⁴ Extreme dipping refers to patients who show a marked ($> 20\%$) nocturnal fall in systolic BP (SBP) and or diastolic BP (DBP), or have a night/day SBP or DBP ratio of < 0.8 .²⁰ Given that the circadian rhythm of BP is predominantly determined not by awake-sleep behavior rather than the day-night cycle,³⁵ the nocturnal dipping status of shift workers should be determined by awake BP (during nighttime) and sleep BP (during daytime).

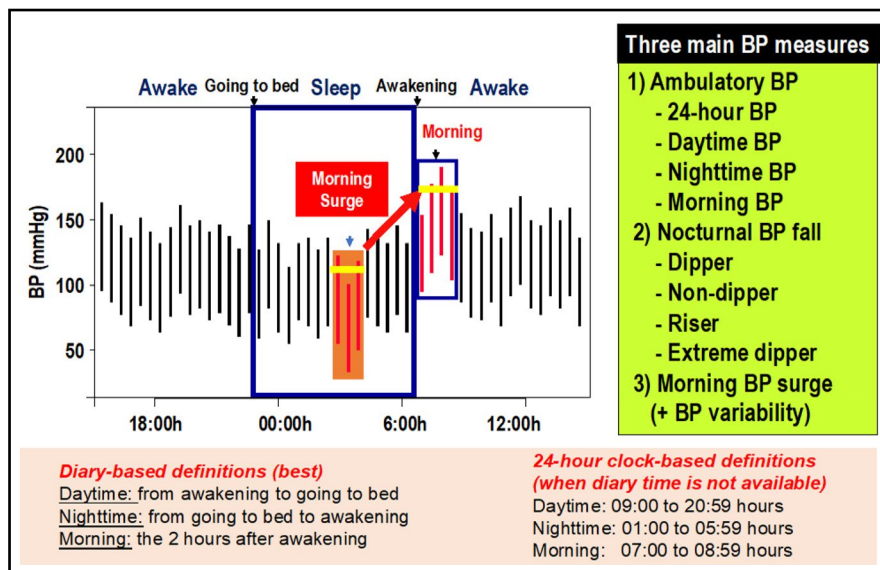


FIGURE 2 Blood pressure measures determined using ambulatory blood pressure monitoring. BP, blood pressure (adapted from Kario et al 2003)⁴¹

Nocturnal BP may be the most reproducible and reliable ABPM parameter for risk stratification.³⁶ Nocturnal hypertension (BP \geq 120/70 mmHg) could indicate the presence of comorbidities such as obstructive sleep apnea (OSA), and the riser pattern of nighttime BP is associated with a particularly poor prognosis with respect to the occurrence of stroke and cardiac events.³⁷⁻³⁹ Stroke risk also appears to be increased in elderly hypertensive patients with an extreme dipper pattern.⁴⁰ Another important BPV parameter is the morning BP surge (the difference between the lowest nighttime BP and morning BP measured 2 hours after awakening). Early morning BP surge is associated with an increased risk of cardiovascular and cerebrovascular adverse events, especially hemorrhagic stroke.⁴¹⁻⁵²

Excessive BPV could result in large dynamic surges that have the potential to trigger adverse cardiovascular events (the resonance hypothesis), and the risk of these events is exaggerated in high-risk patients with vascular disease.⁵³ Greater variability in SBP is a significant independent predictor of mortality.^{54,55}

ABPM data can be used to calculate a number of important measures of short-term BPV, including the standard deviation (SD), coefficient of variation (CV), average real variability (ARV), variability independent of the mean (VIM) for daytime and nighttime BP, weighted SD of 24-hour BP values, and peak and trough values for daytime and nighttime BP.³² However, although short-term BPV has been used successfully for risk stratification, use in clinical practice is currently limited by a lack of accepted thresholds defining normal and pathologic short-term BPV.¹⁹

3 | ASIA-SPECIFIC FEATURES OF THE 24-HOUR BP PROFILE

There is a possibility that Asia-specific features of hypertension include greater salt sensitivity and lower body mass index

compared with Western populations.^{9,10} Prevalence rates for masked (uncontrolled) hypertension, excessive morning BP surge and morning hypertension, and nocturnal hypertension are all higher in Asians than in Westerners.^{46,56-60} There are also ethnic variations in the complications of hypertension. Although coronary heart disease (CHD) is the most common complication of hypertension in Western subjects, the rate of stroke is higher than that of CHD in many of the Asian countries.^{8,12} In addition, the slope of the relationship between increasing BP and the rate of cardiovascular events, especially stroke, is steeper in Asians than in Westerners.^{4,61-63}

4 | WHY IS IT IMPORTANT TO MONITOR AMBULATORY BP?

ABPM is the reference standard, because neither clinic nor home BP measurements alone had sufficient sensitivity or specificity to perform the diagnosis of hypertension compared with ABPM.⁶⁴ ABPM also provides data on several important parameters that cannot be obtained using any other form of BP measurement, including 24-hour BP, BPV (particularly over the short term), nocturnal “dipping status,” and BP morning surge. In addition, ABPM readings reflect an individual's BP in their usual daily environment, allowing the effects of environmental and emotional factors on BP to be determined.^{19,65} Importantly, ABPM measures correlate better with the occurrence of cardiovascular events in patients with hypertension than office BP^{39,66-70} and therefore provides better information with which to manage cardiovascular risk. ABPM parameters have also been associated with target organ damage (TOD) in patients with hypertension (eg, left ventricular hypertrophy, diastolic dysfunction, microvascular disease, atherosclerosis, and cognitive dysfunction).^{42,71-85}

5 | ABPM VERSUS HBPM

In clinical practice, use of ABPM together with HBPM is recommended because ABPM and HBPM provide complementary data.^{19,20,24} The differential features of ABPM and HBPM are shown in Table 1. However, ABPM is preferable to HBPM depending on physicians or clinical situation.⁸⁶ There are a number of reasons for this. Firstly, there is more evidence for the association between antihypertensive treatment and improved cardiovascular outcomes when BP is assessed using ABPM rather than HBPM. Secondly, although HBPM devices may be readily available, many are not validated or reliable, especially if purchased online.⁸⁷ Thirdly, not all patients with hypertension are capable of complying with HBPM monitoring requirements, especially over the longer term.

Nevertheless, data for the association between HBPM parameters and cardiovascular outcomes are accumulating,⁸⁸ and newer HBPM devices can monitor nighttime home BP, which may provide better prognostic information than nighttime BP measured using ABPM.⁸⁹ In Japan in particular, guidelines recommend the initial use of HBPM in patients with hypertension,²² and a variety of validated HBPM devices have been used extensively in clinical practice because device sale is regulated by the government and limited to validated options. Ultimately, the choice of when and how to use ABPM and/or HBPM will depend on the specific health care environment in each country and the currently available evidence.³¹

6 | WHO NEEDS ABPM?

Guidelines recommend the use of out-of-office BP monitoring, including ABPM, to facilitate the diagnosis of hypertension, including detection and confirmation of white-coat hypertension (WCH) and masked hypertension (MH).^{16-18,20-24,26,36,90} Individuals who show unstable and/or variable BP on office or home measurements are ideal candidates for ABPM because these people are more likely to have WCH or MH.¹⁹ ABPM should also be used in patients with advanced TOD, secondary hypertension, drug-resistant hypertension, and to monitor antihypertensive drug therapy.³² ABPM may also be useful for patients working in a stressful environment who are

TABLE 1 Differential characteristics of out-of-office blood pressure measurement tools

	ABPM	HBPM
Convenient	No	Yes
Validated	Yes	Yes (but not all devices)
Evidence for association with cardiovascular outcome	+++	++
Evidence for monitoring drug efficacy	+++	++
Reimbursement	Yes	No

Abbreviations: ABPM, ambulatory blood pressure monitoring; HBPM, home blood pressure monitoring.

TABLE 2 Clinical indications for using ambulatory blood pressure monitoring in addition to home blood pressure monitoring

Indication
Increased BPV on HBPM or abnormal 24-hour BP patterns
Presence of advanced target organ damage
Suspected masked hypertension
Suspected white-coat hypertension
Secondary hypertension
Monitoring of antihypertensive therapy
Treatment-resistant hypertension

Abbreviations: BPV, blood pressure variability; HBPM, home blood pressure monitoring.

suspected of having hypertension, who have been shown to demonstrate higher BP in the worksite compared with morning home BP and office BP.⁹¹ The clinical indications for ABPM are summarized in Table 2.

7 | HOW AND WHEN SHOULD ABPM BE MEASURED?

Use of an ABPM device that has been validated against accepted international standards, with associated software providing the data of interest, is recommended.¹⁹ At a minimum, this should include details of all BP readings showing daytime and nighttime windows with an indication of normal BP, average SBP, average DBP, and heart rate, the percentage change in SBP and DBP at night, and summary statistics for time-weighted average SBP, DBP, and pulse rate for the 24-hour period, daytime, and nighttime, with standard deviations and number of valid BP readings.¹⁹

Use of the non-dominant arm is recommended to obtain good ABPM readings, and an appropriate cuff should be provided.¹⁹ During the day, measures should be taken every 15-30 minutes, while measurements every 30-60 min are adequate at night.¹⁹ Overall, at least 70% of readings throughout the 24-hour period should be valid, and there should be at least 20 valid daytime and at least 7 valid nighttime measurements.⁶⁵ In addition, performing ABPM on a normal workday (rather than the weekend or an unusually restful day) will provide data that best reflects a patient's typical BP profile.⁶⁵

8 | ABPM DIAGNOSTIC THRESHOLDS

Diagnosis of hypertension using ABPM should be made based on the following thresholds (Figure 3): $\geq 130/80$ mmHg for average 24-hour BP (sustained hypertension); $\geq 135/85$ mmHg for average daytime BP (daytime hypertension); $\geq 120/70$ mmHg for average nighttime BP (nocturnal hypertension); and $\geq 135/85$ mmHg for average morning BP (morning hypertension).^{31,32} Diagnosis of WCH is made when office/clinic BP is $\geq 140/90$ mmHg plus all of the following on ABPM: 24-hour BP $< 130/80$ mmHg; daytime BP $< 135/85$ mmHg; nighttime

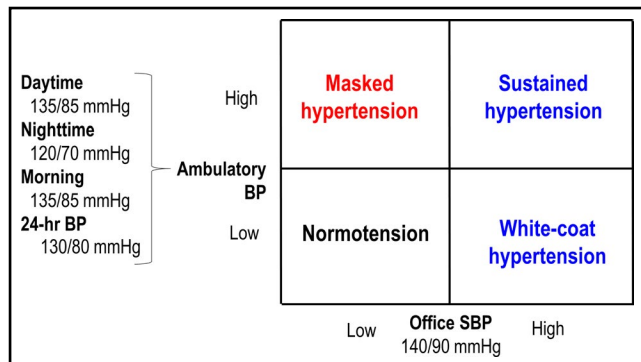


FIGURE 3 Hypertension classifications based on office and ambulatory blood pressure. Source: Kario K. et al,³² *J Clin Hypertens* (Greenwich). 2019; 21:1250-1283

BP < 120/70 mmHg; and morning BP < 135/85 mmHg.^{31,32} Diagnosis of MH is made when office/clinic BP is < 140/90 mmHg plus 24-hour BP \geq 130/80 mmHg, daytime BP \geq 135/85 mmHg (masked daytime hypertension), nighttime BP \geq 120/70 mmHg (masked nocturnal hypertension), and/or morning BP \geq 135/85 mmHg (masked morning hypertension).^{31,32}

9 | ABPM MONITORING OF ANTIHYPERTENSIVE THERAPY

The importance of achieving adequate, consistent reductions in BP cannot be overemphasized. Strict BP control throughout the 24-hour period is important for all patients, but is particularly critical in those of Asian ethnicity.³ Given the greater effect of BP reductions in stroke and heart failure versus CHD,⁹² and the higher rate of these events in Asians,^{8,12} the beneficial effects of BP lowering may be more marked in Asian compared with Western populations.⁴

The only way to reliably monitor the effects of antihypertensive treatment is to repeat ABPM. After good BP control has been achieved and documented, regular reassessment using ABPM will facilitate the maintenance of 24-hour BP control.³² Conventional goal BP thresholds using ABPM are < 130/80 mmHg for average 24-hour

TABLE 3 Ambulatory blood pressure values corresponding to clinic measurements

Clinic BP (mmHg)	Ambulatory BP (mmHg)			
	Daytime	Nighttime	24-Hour	Morning
120/80	120/80	100/65	115/75	120/80
130/80	130/80	110/65	125/75	130/80
140/90*	135/85*	120/70*	130/80*	135/85*
160/100	145/90	140/85	145/90	145/90

Abbreviation: BP, blood pressure. Source: Kario K. et al,³² *J Clin Hypertens* (Greenwich). 2019; 21:1250-1283.

*Pathologic threshold.

BP, <135/85 mmHg for average daytime BP, <120/70 mmHg for average nighttime BP, and < 135/85 mmHg for average morning BP. Applying strict goal thresholds, target BP would be < 125/75 mmHg for average 24-hour BP, <130/80 mmHg for average daytime BP, <110/65 mmHg for average nighttime BP, and < 130/80 mmHg for average morning BP.³²

Adjustment of antihypertensive therapy based on 24-hour data from ABPM has been shown to provide the same level of BP control with less intensive therapy compared with treatment managed using office BP.⁹³ In addition, the proportion of patients achieving target BP in primary care was higher (by up to 26%) when antihypertensive therapy was managed using ABPM compared with office BP.^{94,95} However, there is a lack of current guideline recommendations about how to use ABPM to monitor antihypertensive therapy. Therefore, the best approach might be to base the frequency of ABPM assessments on the risk profile of each patient. Repeating ABPM annually in conjunction with home and office BP readings may be adequate for low-risk patients. In unstable high-risk patients, for whom tight BP control throughout the 24-hour period is particularly important, it might be better to repeat ABPM more frequent, for example, every few weeks.⁹⁶ In patients with treatment-resistant hypertension, use of ABPM allows categorization of patients as having true resistance rather than white-coat resistance,^{97,98} which facilitates appropriate targeting of additional therapeutic interventions.

Calcium channel blocker (CCB) therapy appears to be particularly well suited to the characteristics of Asian patients with hypertension because the BP-lowering activity of these agents is independent of salt sensitivity and salt intake.⁹⁹ Treatment with a long-acting CCB has been shown to be effective for lowering office, home morning, and 24-hour ambulatory BP, and reducing exaggerated BPV, independently of salt intake and salt sensitivity.⁹⁹⁻¹⁰²

Combination antihypertensive therapy is often required to achieve good BP control. Clinical trial data obtained using ABPM indicate that combinations including an angiotensin-converting enzyme inhibitor or angiotensin receptor blocker plus a CCB effectively reduce 24-hour BP and other ABPM parameters (eg, nocturnal hypertension, morning BP surge) in Japanese patients with hypertension.¹⁰³⁻¹⁰⁶ Novel approaches to lowering BP are being investigated in patients with treatment-resistant hypertension, and ABPM has been included as an important assessment tool in trials evaluating renal denervation in this setting.¹⁰⁷⁻¹⁰⁹

10 | ABPM IN ASIA: CURRENT PRACTICE AND BARRIERS TO USE

ABPM devices are widely available in certain Asian countries. However, there are limited data on how this important out-of-office BP monitoring technique is used in routine clinical practice throughout the region. Cost (including reimbursement) and accessibility are potential issues that could limit the use of ABPM in some settings and/or countries,¹¹⁰⁻¹¹² although longer term savings are likely to offset the short-term costs of ABPM use.¹⁹ In Japan, ABPM

is reimbursed by the National Health Insurance scheme, based on the superiority of ABPM over other forms of BP measurement for predicting the development of cardio- and cerebrovascular events, and the cost-effectiveness of this approach.¹¹³ Modeled data estimated that introduction of ABPM for hypertension monitoring in Japan would save 10 trillion yen over 10 years, reduce the number of strokes by more than 59,500, and save almost 19,000 lives.¹¹⁴

In addition to the cost and having access to a validated device, there are a number of factors that contribute to decisions about whether and how often to use ABPM. These include patient engagement and acceptability, physician knowledge and attitude to training, education and training of both the physician and patient, and available resources (both in terms of staffing and funding).³² The perceived complexity of ABPM by patients means that physicians need to allocate adequate time to provide appropriate and thorough education, including letting the patient know that there may be some discomfort during BP cuff inflation.¹⁹

Region-wide strategies are needed to improve access to APBM devices, provide physician training, and develop suitable education materials (supplemental material) to facilitate more widespread use of ABPM in Asia.³²

11 | TELEMEDICINE AND NEW OPPORTUNITIES

New information and communication technology (ICT)-based devices that perform automatic, fixed-interval BP measurement during sleep and store or transmit the data (telemedicine) are now available, and could facilitate a novel approach to manage patients with hypertension.¹¹⁵ Health and information technology (HIT) solutions such as these are becoming recognized as important advances in health care, and the emerging role of HIT was highlighted in the latest version of the American College of Cardiology/American Heart Association hypertension guidelines.²³ Furthermore, a Web-based ABPM recording platform is established in China.¹¹⁶ With this platform, ABPM data are uploaded to the system and analyzed in a remote server. Analyzed data can be forwarded to the patients and physicians. The goal with these devices is to obtain information that allows anticipation of cardiovascular events and early intervention to prevent them. The ultimate aim would be to eliminate cardiovascular events in patients with hypertension altogether. This approach is referred to as "anticipation medicine" for zero cardiovascular events,¹¹⁷ within which BPV is a key biomarker.^{3,118}

12 | CONCLUSIONS

ABPM plays an important role in the diagnosis and management of hypertension, and is recognized as an essential part of good clinical practice in the field. It is currently the only out-of-office BP monitoring technique that can provide information on the 24-hour BP profile, including BPV, nocturnal hypertension, and morning BP

surge, all of which are important predictors of TOD and cardio- and cerebrovascular risk. ABPM is particularly relevant in Asia due to the specific characteristics of hypertension in the region, including greater BPV and a higher rate of nocturnal hypertension, both of which are best identified using ABPM. ABPM also has an important role in the effective initiation and management of antihypertensive therapy and allows determination of 24-hour BP control. The goal of the practice points provided is to help clinicians incorporate ABPM into their everyday practice to help improve patient outcomes.

ACKNOWLEDGMENTS

Writing and editorial support was provided by Nicola Ryan, independent medical writer; this support was funded by Pfizer.

DISCLOSURES

K Kario reports research grants from Omron Healthcare, Fukuda Denshi, A&D, and Pfizer Japan, and honoraria from Omron Healthcare. YC Chia has received speaker honorarium and sponsorship to attend conferences and seminars from Boehringer Ingelheim, Pfizer, Omron, Servier, and Xepa-Soul, and investigator-initiated research grants from Pfizer and Omron. 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. J Shin has received lecture honoraria from Pfizer Inc, Hanmi Pharm. Co. Ltd., Yuhan Co. Ltd., and Boryung Pharmaceutical Co. Ltd.; consulting fees from Hanmi Pharm. Co. Ltd. And Handok Kalos Medical Inc; and research grants from Sanofi Pharm. and Hanmi Pharm. Co. Ltd. CH Chen reports personal fees from Novartis, Sanofi, Daiichi Sankyo, Servier, Bayer, 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; Menarini Co., Ltd.; and served as an advisor or consultant for ApoDx Technology, Inc. JM Nailles has received honorarium and sponsorship to attend conferences and seminars from Pfizer and Omron, and received an investigator-initiated research grant from Pfizer. JG Wang reports having received research grants from Chengdu Di-Ao and Omron, and lecture and consulting fees from AstraZeneca, Novartis, Omron, Servier, and Takeda. All other authors report no potential conflicts of interest in relation to this article.

AUTHOR CONTRIBUTION

K. Kario had the primary responsibility of writing this paper. K. Kario and S. Hoshide wrote the essential part of the manuscript. JG. Wang, YC Chia, P. Buranakitjaroen, S. Siddique, J. Shin, Y. Turana, S. Park, K. Tsoi, CH Chen, HM Cheng, T. Fujiwara, Y. Li, VM Huynh, M. Nagai, J. Nailles, J. Sison, AA Soenarta, GP Sogunuru, A. Sukonthasarn, JC Tay, BW Teo, N. Verma, TD Wang, and Y. Zhang reviewed/edited the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Kario K, Hoshide S, Chia YC, et al. Guidance on ambulatory blood pressure monitoring: A statement from the HOPE Asia Network. *J Clin Hypertens*. 2021;23:411-421. <https://doi.org/10.1111/jch.14128>