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Clinical Update
Hypertension and Cardiology

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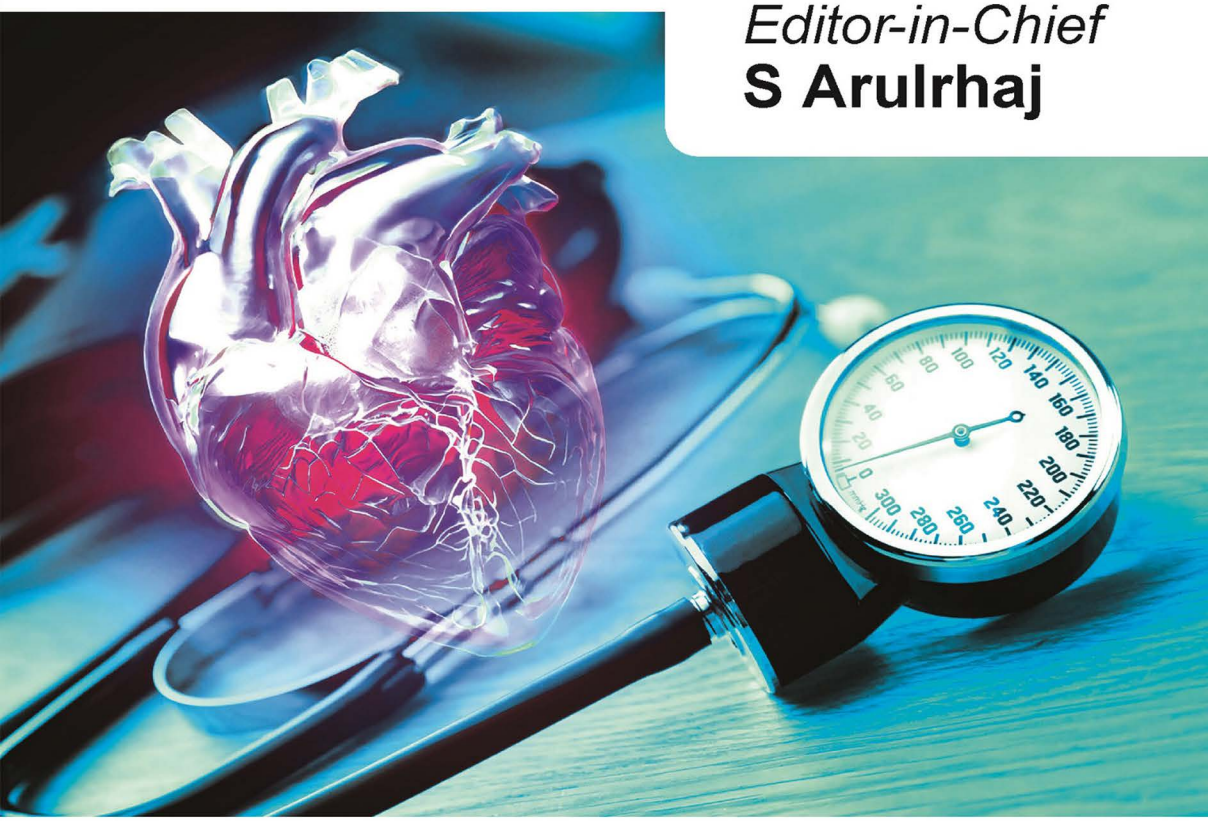

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Contents

1. **Hypertension: A Growing Trend** 1
   P Manokar

2. **Economic Burden of Hypertension Heart Disease in India** 6
   RP Ram

3. **Office Blood Pressure Measurement** 12
   R Hariharakrishnan

4. **Home Blood Pressure Monitoring** 20
   R Hariharakrishnan

5. **Ambulatory Blood Pressure Measurement** 25
   Sundar Chidambaram

6. **Central Aortic Blood Pressure** 32
   P Vinodh Kumar

7. **Hypertension Hypertrophy and Heart Failure: The Continuum** 36
   T Viswanathan

8. **Hypertension and Cardiorenal Hemodynamics** 42
   Ashwin Patil, Sudhiranjan Dash

9. **Hypertension: A Risk Factor for Atherosclerosis** 47
   T Neelambujan

10. **Hypertension and Coronary Artery Disease** 54
    Meenakshi Subbiah

11. **Hypertension and Peripheral Artery Diseases** 61
    Maunil Bhuta

12. **Hypertension and Arrhythmia** 68
    Saurabh Ajit Deshpande

13. **Hypertension and Aorta: Coarctation, Dissection, and Aneurysm** 75
    J Cecily Mary Majella

14. **Biomarkers in Hypertension** 86
    P Ramachandran

15. Role of Electrocardiography and Stress Testing in Hypertensive Patients **91**
Ameya Tirodkar

16. Role of Echocardiography in Hypertensive Patients **99**
Rishikesh Shah

17. Hypertension and Hypertensive Heart Disease Prevention and Treatment with Diet **118**
Prathamesh Deorukhkar, Anita Jaiswal Ektate

18. Exercise and Physical Activity in Hypertensive Heart Disease **122**
Nilesh Tawade

19. Hypertension and Stress **126**
Nihar Mehta, Zakiya E Patni

20. Sleep and Sleep Apnea in Hypertension **131**
Arun Ranganathan, P Deepa

21. Antihypertensive Drug Therapy: Targets, Choices, and Algorithms **136**
Alok Shah

22. Follow-up in Hypertension Management **151**
Nihar Mehta, Zakiya E Patni

23. Hypertensive Emergencies **159**
S Arulrhaj, Aarathy Kannan, Manikandan, Nikhil Govind

24. Hypertension: Interventional Options **172**
Ravindran Rajendran, Vadivelu Ramalingam, Nagendra Boopathy Senguttuvan

25. Future Perspective of Hypertension **177**
Nihar Mehta, Vivek Mandurke

Index **183**

CHAPTER

5

Ambulatory Blood Pressure Measurement

Sundar Chidambaram

INTRODUCTION

Strong scientific evidence proves that ambulatory blood pressure monitoring (ABPM) is an effective noninvasive diagnostic method and a powerful tool for detecting white coat hypertension (WCH), drug-resistant hypertension, nocturnal variation in blood pressure (BP), masked hypertension (MH), sustained hypertension, diminished nocturnal BP fall, and cardiovascular events. This can be used as an effective tool for monitoring intraday fluctuations and nocturnal fluctuations in BP, which in turn can be used to predict cardiovascular risk.[1]

Numerous studies have been carried out on ABPM by the scientific community over the last 50 years. This is evidenced by the scores of articles which are available in PubMed. The recommendations for BP monitoring were published in 2003 by the Working Group on Blood Pressure Monitoring of the European Society of Hypertension (ESH). They also published a guideline for home BP measurement in 2008. ABPM is being strongly recommended by the American Heart Association and American College of Cardiology for the confirmation of hypertension; the effectiveness of ABPM in diagnosing hypertension has also been supported by UK National Institute for Health and Care Excellence (NICE), Canadian Hypertension Education Program, National Heart Federation of Australia, and US Preventive Services Task Force (USPSTF) recommendation statement on high BP screening in adults. The USPSTF recommends the use of 24-hour ABPM as part of screening and diagnosis of hypertension.

The ESH guidelines for office BP (OBP) and out-of-office BP monitoring including ABPM have been updated regularly for the last five decades and the latest update has been published in 2021. The guidelines have been formulated based on the consensus of 35 experts from different countries. This article clearly states that inaccurate detection of BP can lead to unnecessary treatment or exposure to cardiovascular disease which can be treated. The advantages of using state-of-

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the-art ABPM monitors are their cost effectiveness, ease of use, standardization by strict protocols, and reliability. The Centers for Medicare and Medicaid has determined that the evidence is sufficient to cover ABPM for the diagnosis of hypertension in Medicare beneficiaries with WCH and MH under certain circumstances.

DEVICES AND SOFTWARE

Automated electronic ABPM devices have been used widely. Clinical validation protocols have been developed by scientists for the accuracy of these devices. A universal standard was developed by the American Association for the Advancement of Medical Instrumentation, the ESH, and the International Organization for Standardization (AAMI/ESH/ISO) for global use in 2018. It has also been clearly stated that the validation protocols need to be developed for different populations as the protocols developed for adults do not work out accurately for children, pregnant women, and patients with arrhythmias.[2]

Most of the studies have been carried out on the accuracy and validation of ABPM devices, but these have not included the software presentation and analysis of data collected by the ABPM devices. The practicing physician is tasked with interpreting an extensive amount of superfluous detail which is presented in plots and histograms and collecting the necessary information. This article emphasizes the need for stipulating software requirement for ABPM. The plots provided by the software should be available in a single page for a 24-hour period with different windows and a fixed 30-minute interval and clearly marked normal and abnormal bands and clearly demarcated awake and sleep time of the subject. The report generated by the software should also include the summary statistics of readings of heart rate and systolic BP and diastolic BP in different windows of fixed 30-minute intervals within the 24-hour time period and also clearly differentiate awake and sleep periods with the respective sleep deprivation (SD), and the data should also include the number of valid readings. The report containing the normal and abnormal readings should be automated as it is done in electrocardiogram (ECG) monitoring; this should be done to prevent the variance associated in the interpretation by various individuals and to help those who are not familiar with the interpretation of the data generated by the ABPM device. Allowance should also be made for the creation of reports over time for determining the efficacy of the treatment regimen. The ABPMs should also have the capability of storing data over extended time periods for conducting research and data useful for national registries and national healthcare agencies.[3]

AMBULATORY BLOOD PRESSURE MONITORING THRESHOLDS FOR CLINICAL PRACTICE

Table 1 illustrates the ABPM thresholds for hypertension diagnosis as approved by ESH.

As per the NICE guideline 2019, those with clinic BP of 140/90 mm Hg or higher and ABPM daytime average or home blood pressure monitoring (HBPM) average of 135/85 mm Hg or higher have been diagnosed to be hypertensive.[4]

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TABLE 1: Ambulatory blood pressure monitoring (ABPM) thresholds for hypertension diagnosis as approved by the European Society of Hypertension (ESH).

Interpretation		
ABPM thresholds for hypertension diagnosis		
24-hour average	≥130/80 mm Hg	Primary criterion
Daytime (awake) average	≥135/85 mm Hg	Daytime hypertension*
Nighttime (asleep) average	≥120/70 mm Hg	Nighttime hypertension*
Asleep blood pressure (BP) dip compared to awake BP (systolic and/or diastolic)		
Asleep BP fall	≥10%	Dipper*,†
	<10%	Nondipper*,†

* Apply only if day/night BP is calculated using the individuals' sleeping times.

† The diagnosis must be confirmed with repeat ABPM.

NUMBER OF MEASUREMENTS FOR A SATISFACTORY AMBULATORY BLOOD PRESSURE MONITORING

The ESH guidelines 2013 (2) position paper states that there is no firm data available to base recommendation for a satisfactory ABPM recording. It clearly states that ABPM recording should have ≥70% of expected measurements in the clinical practice setting. It was recommended in the previous ESH guideline that there should be 14 readings during the day during the awake period (0900–2100 hours) and seven measurements during the sleep period (0100–0600 hours) with measurements being performed every 30 minutes or more frequently through the entire 24-hour period. This period helps in eliminating the variation in the sleep–awake periods which exists between different age groups in the same population and between different populations with different ethnicities. It has been found that increasing the daytime readings to 20 while keeping the nighttime readings as seven with readings being taken every 30 minutes would be reasonable for generating accurate results.[5]

DIAGNOSIS OF HYPERTENSION

The NICE guideline 2021 recommends offering ABPM to patients if clinic BP is between 140/90 and 180/120 mm Hg to confirm the diagnosis of hypertension. The ESH states that the diagnosis of hypertension should be confirmed by HBPM or ABPM. As per the ESH, this should be particularly carried out in untreated or treated individuals with OBP levels within the grade 1 hypertension range (140–159/90–99 mm Hg). HBPM or ABPM is strongly recommended because of increased probability of WCH; similar is the case with high-normal OBP levels (130–139/85–89 mm Hg) as they have increased probability of MH. Several studies which have been carried out till date confirmed that ABPM should be used for the exclusion or diagnosis of WCH, for studying the efficacy of a drug regimen, for identifying MH, and for the diagnosis of resistant hypertension.[6] It is imperative that ABPM services be provided by all the countries to improve the cardiovascular health by improved management and early detection of hypertension.

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WHITE COAT HYPERTENSION

Subjects with WCH have elevated BP readings in the clinic setting and normal BP readings outside clinic setting. WCH should only be applied to subjects who are not on any antihypertensive drug regimen. This makes them suitable candidates for identifying variable 24-hour BP profile. The ESH states that subjects are diagnosed with WCH when they have a reading of at least 140/90 mm Hg in the clinic and a mean 24-hour BP of <130/80 mm Hg. It has been scientifically proven that around 15–30% of those with hypertension are deemed to have WCH. ABPM has been widely used by physicians and recognized as the gold standard for detecting WCH by NICE. The NICE guideline strongly advocates the use of ABPM for ruling out WCH in patients aged >18 years who have elevated BP in the office setting. The USPSTF recommends obtaining measurements outside of the clinical setting for diagnostic confirmation before starting treatment. It considers ABPM as the best confirmatory test for diagnosing hypertension and ruling out WCH. Three to six months follow-up visits are necessary for those with WCH, and these patients should be followed with ABPM every year.[7]

WHITE COAT EFFECT

White coat effect (WCE) is often defined as the difference between OBP and average daytime ambulatory BP or the use of antihypertensive drugs. This is considered as the response of BP to the clinic visit. This is more common in hypertensive individuals. The OBP is high and the out-of-office BP is normal in WCH whereas in WCE, the OBP is more than the normal awake BP. WCE may lead to the misdiagnosis of resistant hypertension. Patients with an OBP ≥20 mm Hg systolic or 10 mm Hg diastolic higher than the awake ambulatory BP only should be deemed to have WCE. This needs to be addressed with caution, and the changes should not be associated with WCE in all the circumstances. The BP taken at the office and the BP reading in the ABPM during the office visit should be cross verified.

MASKED HYPERTENSION

Masked hypertension is defined as normal BP in the clinic (<140/90 mm Hg), but an elevated BP as recorded by ABPM out of the clinic (ambulatory daytime BP or home BP >135/85 mm Hg). Nocturnal BP also should be considered for detecting MH as opposed to only taking daytime BP into account. MH does not apply to individuals on antihypertensive medication. Individuals on antihypertensive medication exhibiting normal BP in the office and elevated BP out of office are considered to have masked uncontrolled hypertension. The medication regimen of such patients needs to be adjusted to prevent cardiovascular risk and organ damage. The superiority of ABPM over automated office and HBPM comes into play while detecting nocturnal hypertension and daytime hypertension in individuals with masked uncontrolled hypertension. ESH practice guideline (2021) and NICE guideline (2019) recommend the use of ABPM in addition to clinic BP measurement for people who have conflicting clinic and nonclinic BP measurements which include those with WCH and those with MH.

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Nocturnal Blood Pressure

There is compelling evidence that mean nighttime BP levels can serve as sensitive predictors of cardiovascular morbidity and mortality. The absence of nocturnal BP dipping or a high daytime–nighttime ratio not only is a risk factor for cardiovascular disease but also serves as a predictor for the underlying diseases which lead to nocturnal elevation in BP. Several studies have corroborated that nocturnal BP measurements are superior to daytime BP measurements for the prediction of cardiovascular events. ABPM can detect circadian changes in BP. Isolated nocturnal BP elevation, which is exhibited in 7% of hypertensive patients, can solely be diagnosed by ABPM.

There are two methods for the measurement of nocturnal BP. The first method uses a sleep diary where the subject marks the waking and sleeping hours; if the subject takes a daytime nap which is not marked, it might lead to erroneous calculation of nighttime dip in BP. The second method uses either wide (from 2200 to 0600 hours) or narrow (from midnight to 0600 hours) time intervals. The narrow time interval method is an effective way to calculate the nocturnal dips in BP as the transition period between day/night and night/day is excluded. A dip in nighttime BP by 10–20% is considered to be normal and that below 10% is considered as blunted or absent.[8]

Studies regarding the therapeutic modification for nocturnal hypertension are very few. Therapy aimed at controlling BP during the 24-hour period, which includes nocturnal BP elevation, should be the goal for the effective treatment of hypertension.

REPETITION OF AMBULATORY BLOOD PRESSURE MONITORING

There have been many discussions regarding the repetition of ABPM. The repetition is based on the clinician's recommendation and the availability of ABPM. ABPMs need not be used frequently for patients with mild elevation in BP and those who do not have any end-organ damage. However, it has been agreed universally that ABPM should be repeated in individuals who have uncontrolled hypertension, those with end-organ damage, those who have comorbidities such as diabetes, and those with a family history of cardiovascular disease.[9]

HOME BLOOD PRESSURE MONITORING

The diagnostic utility of ABPM in clinical practice is immense. It is helpful in diagnosing sustained hypertension, ruling out WCH, detecting MH, diagnosing nocturnal hypertension, detecting nocturnal dips in BP, and diagnosing autonomic dysfunction. The greatest advantage is that it provides accurate information, and there is no special skill set or training needed by the patient for using this device.

Out-of-office BP measurements or home BP measurements can be used when ABPMs are not available. The ESH recommends taking duplicate measurements in the mornings and evenings for 7 continuous days and calculating the average after excluding the measurements taken on day 1. Home BP measurement plays an important role in monitoring BP between subsequent office visits. This is an

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effective method for those who have had good BP control on ABPMs, and this also serves as a motivation for adhering to the therapeutic regimen for controlling hypertension.

BLOOD PRESSURE VARIABILITY

Blood pressure is a dynamic entity and variations in BP occur throughout a subject's life. The fact that BP variability is a risk factor for cardiovascular disease is a proven fact. BP variability can be classified as short-term BP variation and long-term BP variation. Short-term BP variability encompassed the variation that occurs over seconds, minutes, and hours within a 24-hour period. Long-term BP variability is described as BP variability which occurs between office visits over a long period of time. BP variability might be either erratic or exhibit a characteristic pattern which includes nighttime dip and morning surge. Scientific literature reiterates the fact that BP variability as opposed to mean BP levels is more sensitive in predicting cardiovascular events. There is a strong association between short-term BP variability, otherwise called exaggerated circadian BP variations, and cardiovascular events, target organ damage, and mortality. Short-term BP variation is a better indicator of cardiovascular events when compared to long-term BP variation. Research is needed on the efficacy of hypertensive therapy on the effect of short-term variability of BP. It has been well proven that ABPM is the most efficient method for measuring short-term BP variation.[10]

COST BENEFITS AND AVAILABILITY OF AMBULATORY BLOOD PRESSURE MONITORING

The economic advantage and cost effectiveness of ABPM have been confirmed by the NICE study which evaluated BP in a population suspected to have high BP. The study stated that using ABPM would result in substantial savings for National Health Service (NHS). This study excluded the cost benefits which would be achieved in terms of reduction in drug costs due to effective monitoring and reduced costs in terms of treating stroke and other cardiovascular outcomes resulting due to undetected high BP. Similar studies have been carried out in numerous countries including India, United States of America, Australia, and Japan.

The cost of ABPM varies among different countries, and the reimbursement for using ABPM by medical professionals by government and private insurance providers also varies. It would help the healthcare providers and patients if there is consensus among the national healthcare systems, government health insurance reimbursement schemes, and private medical insurance providers regarding the reimbursement for ABPM.

AUTHORIZED PROVIDERS OF AMBULATORY BLOOD PRESSURE MONITORING

There is considerable variation in the healthcare structure in many countries. Hypertension is generally diagnosed and managed by primary care providers (PCPs) and general physicians in most cases. PCPs can provide ABPM service or they

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could refer the patients to external ABPM services and follow the referral protocol which is used for common laboratory tests and diagnostic imaging. Various models which plan to rope in specialist clinics, healthcare providers in the private sectors, and pharmacists as ABPM providers have been tested in many countries.

The role of pharmacists in helping patients control hypertension is immense. Studies have proven that patients have better control of BP when pharmacists are involved. The model which ropes in pharmacists as ABPM service provides along with the PCP would work out to be very efficient. This would help the patients with better high BP control and would also increase the productivity of PCPs to see additional patients.

CONCLUSION

It has been proven beyond doubt that ABPM is the most diagnostically accurate and cost-effective method for detecting elevated BP in subjects suspected to have hypertension. This fact has been confirmed by a large number of studies.

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- Specialized chapters to address topics such as hypertensive emergencies, hypertension, and interventions
- The compendium explores both fundamental and practical aspects linking hypertension and cardiology, including epidemiology, risk, treatment, and secondary causes
- A comprehensive guide for diagnosis and management of hypertension
- Inclusion of treatment of hypertension with associated cardiovascular conditions with lifestyle management as an integral part for hypertensives and prehypertensives
- Promotes the research potential of understanding advances and innovations in the domain of hypertension and cardiology
- Practical value to doctors around the world who treat patients with hypertension every day.
- Language has been made in such a way that it will be of interest to undergraduates, postgraduates, physicians, general practitioners, practicing cardiologists, and researchers

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