Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.234154.2873 Volume 30, Issue 7, Oct. 2024
Manuscript ID ZUMJ-2407-3465 DOI . 10.21608/ZUMJ.2024.302545.3465

REVIEW ARTICLE

Practical Importance of Ambulatory Blood Pressure Monitoring

RagabAbdelsalam Mahfouz, Mohammed Abdallah Elsayed Ali*, Tamer Mustafa, Islam Ghanem Ahmed

Cardiology Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

Corresponding author*
Mohammed Abdallah Elsayed Ali

E-Mail:
dmhmdbdallh1@gmail.com

Submit Date: 08-07-2024
Revise Date : 23-07-2024
Accept Date: 28-07-2024

ABSTRACT

Background: Blood pressure can be monitored during regular activities like resting and light to moderate activity using ambulatory blood pressure monitoring (ABPM). The majority of the most current major hypertension guidelines suggest using it as a blood pressure measurement technique at home. Numerous studies now available demonstrate that when it comes to monitoring blood pressure and forecasting the risk and occurrence of cardiovascular (CV) events, ABPM is more accurate than office blood pressure disease. Many studies have shown that ambulatory blood pressure especially at night is a more reliable indicator of cardiovascular issues and overall mortality than office blood pressure. By cross-classifying patients according to their office and ambulatory blood pressure readings, it is possible to differentiate between those with white-coat hypertension and those with persistent hypertension, as well as between those with masked hypertension and normotension. White-coat hypertension was not associated with high CV risk, whereas concealed and chronic hypertension were. This review article's goal is to assess ambulatory blood pressure monitoring's utility.

Conclusions: ABPM is acknowledged as a crucial component of excellent clinical practice in the field and plays a significant role in the diagnosis and treatment of hypertension. This is the only method of blood pressure monitoring available outside of an office that can give data on the 24-hour blood pressure profile, which includes nocturnal hypertension, morning blood pressure rise, and BPV. These factors are all significant indicators of TOD as well as cardiovascular and cerebrovascular risk.

Keywords: Ambulatory Blood Pressure; cardiovascular; Hypertension; BPV.

INTRODUCTION

In clinical practice, the relationship between hypertension and target organ the harm has been established. All things considered, for every 20 mm Hg increase in systolic blood pressure (SBP) or every 10 mm Hg increase in diastolic blood pressure (DBP), the risk of a fatal coronary event and stroke doubles **[1]**.

Blood pressure variability is entity that characterizes the continuous and dynamic fluctuations that occur in blood pressure levels throughout a lifetime[2].

It is currently believed that blood pressure variability, or BPV, is a new risk factor for cardiovascular disease. In addition to being complex, BPV is also short-term (lasts minutes to hours) and long-term (lasts days to months) fluctuations. It can be calculated using several statistical techniques and blood pressure (BP) equipment (mostly ambulatory BP monitoring [ABPM]) utilizing various weighted standard deviation or average actual variability methods**[3]**.

Many clinical investigations conducted in the last few years have suggested that either short- or long-term blood pressure variation

(BPV) in individuals with hypertension, diabetes mellitus, chronic kidney disease, and obstructive sleep apnea independently affects target organ damage, cardiovascular events, and mortality**[4]**.

As a result, improving BPV has been proposed as an extra therapeutic goal for individuals with cardiovascular illnesses. The discovery of novel risk variables, including the level of serum uric acid and locomotive syndrome, that are connected to elevated blood pressure variation (BPV) is also receiving more attention**[5]**.

However, individuals with acute coronary syndrome (ACS) frequently exhibit vasomotor instability, which heightens the likelihood of heightened reactions to antihypertensive medication, resulting in early blood pressure fluctuations during ACS treatment. Taking into account the contentious questions surrounding the clinical relevance of BPV in cardiovascular disorders and the paucity of research on BPV's impact in ACS patients**[6]** .

The study by Hassan et al. provides new information by showing that short-term blood pressure variability, as measured by ambulatory blood pressure monitoring (ABPM), is an independent predictor of major adverse cardiovascular events (MACEs; e.g., death, myocardial reinfarction, stroke, heart failure, hypertensive crisis, life-threatening arrhythmia) in both normotensive and hypertensive hospitalized patients with ACS**[7]** .

This review's objective was to assess ambulatory blood pressure's utility monitoring.

Classic and novel Blood pressure (BP) monitoring methods

The arterial site where blood pressure is measured and the time of the reading are related to both blood pressure levels and blood pressure variation. Only the implantation of an intra-arterial catheter allows for the direct assessment of the mechanical strain that an individual artery tree segment experiences due to blood pressure (BP); non-invasive studies that use the arm-cuff method can only produce an approximated result. Additionally, because of systolic blood pressure amplification from the aorta to the periphery, central (aortic) systolic blood pressure levels are lower than equivalent brachial BP levels**[8]**.

The components of BPV that are depending on artery site and timing, along with these methodological problems, significantly lower the accuracy of BPV assessments made using both traditional and innovative blood pressure monitoring techniques. The methods that are currently in use for measuring blood pressure variability (BPV) include a number of benefits and drawbacks. They can be used to measure BPV both in regular, static circumstances as well as in everyday activities or even in dynamic ones figure 1**[9].**

Intra-arterial versus non-invasive cuff-based methods

The invasive intra-arterial technique is supposedly the gold standard for evaluating blood pressure and short-term blood pressure variation, which offers direct assessment of BP levels. The rate and degree of target-organ damage, as well as the most significant finding that BPV was predictive of disease progression were linked to each other in two investigations assessing intra-arterial blood pressure recordings for a full 24-hour period in patients admitted to hospitals due to essential hypertension. There are, however, still little data indicating the clinical significance of BPV as determined by intra-arterial measures. In fact, these kinds of

examinations can only be carried out in a hospital or laboratory, and usually on a restricted group of individuals who have medical issues that necessitate catheterization. In addition, intrusive procedures are expensive, need technical know-how, and may result in discomfort as well as possibly dangerous side effects**[9]**.

Even though non-invasive upper arm cuff blood pressure measurements don't yield the same blood pressure numbers as intra-arterial blood pressure readings, they are still the most effective method for identifying and managing hypertension. Findings from a meta-analysis of research contrasting brachial cuff blood pressure readings with intra-arterial blood pressure readings revealed that the latter significantly underestimated pulse pressure by overestimating intra-arterial diastolic blood pressure levels (by 5-7 mmHg per measurement) and underestimating systolic blood pressure levels. This distinction holds true for both automated oscillometric arm-cuff measurements and manual auscultatory methods, as the latter were designed to mimic blood pressure auscultatory techniques as opposed to intra-arterial blood pressure measurement **[10]**.

Notably, research employing all information about the risks of high blood pressure and the benefits of therapeutic blood pressure lowering comes from upper-arm cuff blood pressure measures, especially in the workplace in reducing cardiovascular morbidity and death. Because upper-arm cuff blood pressure measures were the only ones used in earlier research, it follows that, in order to facilitate data comparison between trials, Any BP clinical trials in the future will automatically select this measurement as their primary methodology. Furthermore, every new blood pressure monitoring technology must be evaluated in comparison to standard upper-arm cuff auscultatory blood pressure readings**[9]**.

Central BP levels and variability

From a pathophysiological perspective, brachial blood pressure levels may not adequately reflect the hemodynamic load on target organs as central (aortic) blood pressure levels do. Vast meta-analyses have demonstrated that central systolic blood pressure levels have independent predictive value for cardiovascular outcomes and are stronger correlation with indicators of injury to the target organ than their brachial counterpart. Nonetheless, according to the predictive ability of peripheral blood pressure levels is not significantly higher than that of central systolic blood pressure levels, just somewhat so**[11]**.

With commercially accessible non-invasive technologies that allow for Central blood pressure can now be estimated using 24-hour ABPM and office readings. In order to capture pressure or substitute signals (such oscillometry, applanation tonometry, and ultrasound), various devices employ distinct principles. To acquire central blood pressure measurements, they employ different calibration techniques. Because of this, the blood pressure readings that these devices provide can vary greatly depending on the approach used. Furthermore, the absence of a consistent validation process for evaluating the Because of these devices' accuracy, there is ongoing debate regarding both their clinical utility and accuracy **[11]**.

The clinical significance of BPV as determined by ambulatory central blood pressure monitoring using the Mobil-O-Graph gadget has been the subject of several research' findings. In one study, Individuals with hypertension and target-organ injury had

higher central and brachial ambulatory blood pressure values (BPVs); however, central BPVs did not contribute any additional important information beyond what brachial BPVs already supplied **[12]**. According to the SAFAR investigation, 24 hour central systolic blood pressure variability (BPV) was significantly and marginally more strongly associated than brachial BPV with carotid damage and left ventricular structural and functional abnormalities in people with hypertension **[13]**.

Office BP readings and BPV

When evaluating the regularity of blood pressure management in individuals undergoing hypertension treatment, in addition to long-term, visit-to-visit blood pressure monitoring readings are utilized. While there are more data available for office-based blood pressure monitoring (BPV) to predict cardiovascular results compared to ambulatory or home BPV, the pharmacological therapy (dosing time and compliance), and the measuring methods (e.g., number of visits or use of standardized procedures) affect office BPV's prognostic value. Crucially, office blood pressure values do not reveal the dynamic variations in blood pressure caused by ordinary daily activity **[14].**

Home BP monitoring and BPV:

Multiple blood pressure measurements in a person's typical setting are provided via at-home blood pressure monitoring, which also eliminates the phenomena of masked and white-coat hypertension. In many nations, HBPM devices are extensively utilized, and patients find this approach to be both patient-acceptable and reasonably priced when used consistently. The most effective technique HBPM is increasingly used for patients getting hypertension treatment to monitor them over the long term. Users of HBPM must get training, and it should only be used under medical supervision **[8]**.

Even though it's common knowledge how important it is to utilize validated devices, most devices on the market lack adequate accuracy validation, and cuff sizes are frequently used incorrectly. Furthermore, this approach does not provide BP readings of the person while they are sleeping, working, or engaging in regular daily activities. It simply delivers static snapshot data. Notably, several cutting-edge, inexpensive HBPM devices can record automatic blood pressure readings while you sleep **[8]**.

While they may potentially yield data on long-term BPV, HBPM devices are primarily utilized for the assessment of mid-term BPV (over days). Because HBPM may provide a considerably higher number of measurements over time than in-office BP measurement, it portrays BPV more accurately. But both approaches assess blood pressure under constrained circumstances (the environment, posture, and procedure followed), which distort and thereby underestimate actual blood pressure variation**[14]**.

Ambulatory BP monitoring and BPV

Blood pressure is a dynamic phenomena that represents the hemodynamic state. As a result, blood pressure varies over short and extended periods of time; this phenomenon is known as blood pressure variability (BPV). The time of day, seasonal effects, genetics, mechanical forces generated during ventilation, local vasomotor phenomena, electrolytes, neurohumoral variables, sympathetic nervous system activity, physical activity, artery wall thickness, and baroreflex mechanisms, as well as possibly environmental factors are among the factors that contribute to brain tumors (BPV) **[15]**.

The significance of various BP profiles and BPV is becoming more widely acknowledged. One method for determining these profiles and variability is the ABPM, which enables Patients will be divided into different groups based on their BP phenotype **[16]** . Daytime was defined as the period from waking to bed, nighttime as the period from bed to awakening, and morning as the period two hours following waking, according to a clock Figure 2[17].

Generally speaking, Daytime blood pressure is higher and nighttime blood pressure is lower (or during periods of sleep). A drop in blood pressure of less than 10% during the night is classified as non-dipping, while a physiological fall of more than 10% is expected. Patients who exhibit Blood pressure rises in people with a riser (or reverse dipping) pattern as they sleep, perhaps reaching higher levels than during the day (blood pressure fall of less than 0%) (nocturnal hypertension). Extreme dipping patients have a night/day SBP or DBP ratio of less than 0.8, or they have a notable (>20%) reduction in the diastolic (DBP) and/or systolic (SBP) blood pressure over night. Since the day-night cycle rather than awake-sleep behavior mostly drives the circadian rhythm of blood pressure, shift workers' nocturnal dipping status should be determined by their blood pressure during the day and their blood pressure during the night **[18]** .

The most consistent and dependable ABPM metric for risk classification might be nocturnal blood pressure. Nocturnal hypertension may be an indication of the existence of comorbidities such as obstructive sleep apnea (OSA) (BP ≥ 120/70 mmHg), and the higher pattern of nighttime BP is linked to an especially unfavorable prognosis for the incidence of stroke and cardiac events. Senior hypertensive patients with an excessive dipper pattern appear to have an elevated risk of stroke as well. Forty An elevated risk of cardiovascular and cerebrovascular adverse events, especially hemorrhagic stroke, is associated with the early morning blood pressure spike **[19]**. Another important BPV measure is the morning blood pressure spike. It is the difference between the blood pressure readings taken two hours after waking up and the lowest reading from the previous night.

According to the resonance theory, high-risk individuals with vascular disease have an increased chance of adverse cardiovascular events, which could be caused by massive dynamic surges brought on by excessive blood pressure variation. Higher SBP variability is a noteworthy independent mortality predictor**[20]**.

The 24-hour blood pressure measurements' weighted standard deviation (SD), coefficient of variation (CV), average actual variability (ARV), variability independent of the mean (VIM), peak and trough values, and daytime and nighttime blood pressure are among the significant metrics of short-term BPV that can be computed using ABPM data. Although short-term blood pressure variability (BPV) has proven effective in risk stratification, there are currently no established thresholds that distinguish between normal and pathologic short-term BPV, which limits its application in clinical practice **[21]**.

Why is it important to monitor ambulatory BP?

Since neither at-home nor clinic blood pressure readings alone had the sensitivity or specificity to diagnose hypertension when compared to ABPM, ABPM is the accepted standard. Aside from BP measurement, ABPM offers information on a number of significant factors that are not available with

other methods. These parameters include BPV (particularly in the short term), 24-hour BP, "dipping status" at night, and BP surge in the morning. Furthermore, an individual's ABPM measurements provide insight into their blood pressure in their typical daily setting, making it possible to assess the impact of emotional and environmental factors on blood pressure **[22]**.

Crucially, office blood pressure does not correlate as well with the frequency of cardiovascular events in those with high blood pressure as ABPM measurements do. This means that ABPM measurements offer more accurate information for managing cardiovascular risk. ABPM values have also been connected to target organ damage (TOD) in hypertension patients, including left ventricular hypertrophy, diastolic dysfunction, microvascular disease, atherosclerosis, and cognitive impairment **[23]**.

Complementary roles of ABPM and HBPM

Compared to snapshot office measurements, both ABPM and HBPM allow several blood pressure readings to be taken in each person's typical environment, resulting in a more comprehensive and accurate analysis of the blood pressure profile. But in roughly 15–25% of cases, when a single technique was used to confirm the diagnosis of hypertension, it has been demonstrated that these two approaches are inconsistent in diagnosing white-coat or masked hypertension **[1]**.

This result is not unexpected considering that the two methods' repeatability is not perfect and that they evaluate distinct facets of the blood pressure profile and behavior (for instance, an increase in blood pressure may occur only during sleep, at home, or at work). As a result, it is best to think of ABPM and HBPM as complimentary techniques rather than interchangeable ones and to use both for a more thorough evaluation of blood pressure variance and average blood pressure. Aside from traditional ABPM and HBPM monitors, blood pressure monitors in the form of wearable watches featuring a small wrist cuff have also been developed. These devices can measure blood pressure at any time of day upon request from the user and are presently undergoing accuracy validation **[24].**

Cuffless wearable BP devices and BPV

Cuffless blood pressure devices are a continuously evolving field of cutting-edge technology. These devices utilize a range of characteristics and methodologies, including pulse transit time, pulse wave analysis, photoplethysmography, and applanation tonometry, to evaluate blood pressure levels. They serve different purposes, Examples of such gadgets are wearables designed for occasional usage or for continuous monitoring over a short period in an intensive care unit [25].

Wearable devices and smartphones with cuffless BP technologies can collect numerous or uninterrupted measures over extended periods of time, without causing discomfort from limb compression caused by cuffs. Thus, these devices have the capability to offer comprehensive data regarding the accurate blood pressure profile and its patterns over a period of time, encompassing all forms of blood pressure variability, ranging from short-term to long-term variability. They have significant potential for applications such as screening, early detection, continuous monitoring, and effective treatment of hypertension. There is presently a wide variety of cuffless blood pressure devices available for purchase, each utilizing distinct technologies and designed for different purposes [25].

Typically, these devices need to be calibrated

for each user. This is done by either entering a blood pressure (BP) the value can be determined either by utilizing an upper-arm-cuff device or by inputting basic demographic data that is known to be associated with BP level, such as age and sex. Periodic recalibration is required at regular intervals, which might be performed every few hours, days, or weeks. However, cuffless devices have certain accuracy issues that are not present in automated cuff blood pressure monitors. These considerations encompass the need for unique user calibration and the dubious accuracy of monitoring blood pressure variations after calibration [25] .

It is crucial to note that the current validation criteria, which are meant to assess the precision of blood pressure devices with cuffs, are not suitable for devices that do not require cuffs. Currently, the International Organization for Standardization (ISO) is in the process of creating a new standard specifically designed to validate continuous cuffless blood pressure (BP) monitors, known as ISO 81060-3. Until there are established standards for validating cuffless blood pressure (BP) devices and thorough investigations into their accuracy and clinical value, it is not advisable to suggest them for medical decision-making, diagnosis, or therapy [26].

Moreover, while cuffless wearable devices appear to be well-suited for assessing both immediate and prolonged blood pressure variability (BPV), there is still a scarcity of clinical evidence and practical applications supporting their effectiveness. When all the above research and accuracy issues of cuffless devices are adequately addressed and resolved, they might become the preferred technique for assessingboth average blood pressure levels and blood pressure variability [8].

Indices of blood pressure variability (BPV):

Internal cycles have an impact on the fluctuation of blood pressure levels, to a larger degree, by the physical and mental effort involved in everyday activities. BPV, or blood pressure variability, is categorized and evaluated in various ranges based on the time frame of assessment. These ranges include the time scales can be categorized as very short-term (beat-to-beat), short-term (within 24 hours, minute-to-minute, hour-to-hour, and day-to-night), mid-term (day-to-day), and long-term (visit-to-visit throughout weeks, months, and years) **[16]**.

The various classifications of BPV involve intricate, ongoing, and ever-changing interactions between internal mechanisms (regulatory neurohormonal and cardiovascular) mechanisms and extrinsic (environmental and behavioural). These classifications are crucial for maintaining the stability of blood pressure, known as 'homeostasis,' and ensuring sufficient blood flow to vital organs in different circumstances [14] .

Conversely, an elevation in blood pressure variability (BPV) can indicate changes in the way the cardiovascular and renal regulatory mechanisms function and are structured. It can also be a sign of hidden or known Cardiovascular harm, or underlying clinical issues associated with autonomic dysfunction, which in turn are linked to poor prognosis. Regardless of the consequences of an increase in blood pressure variability (BPV), the continuously fluctuating nature of blood pressure is unavoidable posed issues in accurately assessing BP levels and diagnosing and classifying hypertension (Figure V) [9].

Ambulatory Blood Pressure Monitoring

(ABPM) diagnostic thresholds

The determination of hypertension diagnosis utilizing Ambulatory Blood Pressure Monitoring (ABPM) is necessary according to specific thresholds. These thresholds are as follows: for sustained hypertension, the average 24-hour BP should be ≥130/80 mmHg; for daytime hypertension, the average daytime BP should be ≥135/85 mmHg; for nocturnal hypertension, the average nighttime BP should be ≥120/70 mmHg; and for morning hypertension, the average morning BP should be ≥135/85 mmHg (Figure 3). White coat hypertension (WCH) is diagnosed when the blood pressure measured in a medical setting is equal to or greater than 140/90 mmHg, and the following criteria are met during ambulatory blood pressure monitoring (ABPM): The mean blood pressure for a 24-hour period should be below 130/80 mmHg, the mean blood pressure during the day should be below 135/85 mmHg, the mean blood pressure during the night should be below 120/70 mmHg, and the mean blood pressure in the morning should be below 135/85 mmHg. The diagnosis of MH is confirmed when the blood pressure recorded in a medical setting is lower than 140/90 mmHg, and the blood pressure assessed over a 24-hour period is equal to or higher than 130/80 mmHg. In addition, daytime blood pressure should be at least 135/85 mmHg, indicating masked midday hypertension. Nighttime blood pressure should be at least 120/70 mmHg, indicating masked nocturnal hypertension. Morning blood pressure should be at least 135/85 mmHg, indicating masked morning hypertension **[20]**.

Ambulatory Blood Pressure monitoring of antihypertensive therapy

The importance of achieving adequate and consistent reductions in blood pressure cannot be overstated. Maintaining strict blood pressure control at all times is crucial for all patients, but it is especially vital for individuals of Asian origin. According to **Ueshima [27],** Given the greater influence of lowering blood pressure on stroke and heart failure in comparison to coronary heart disease (CHD), as well as the higher prevalence of these occurrences among Asians, it is likely that the beneficial benefits of reducing blood pressure may be more noticeable in Asian individuals when compared to Western cultures.

To accurately evaluate the effects of antihypertensive medication, it is necessary to perform Ambulatory Blood Pressure Monitoring (ABPM) is a method used to measure and record blood pressure over a period of time while the person is going about their daily activities. When blood pressure is managed optimally has been successfully attained and recorded, periodic evaluation utilizing Ambulatory blood pressure monitoring (ABPM) helps maintain continuous management of blood pressure over a 24-hour period. The recommended target blood pressure thresholds utilizing the key components of ambulatory blood pressure monitoring (ABPM) are: Below 130/80 mmHg is considered the average 24-hour blood pressure, less than 135/85 mmHg for the average daytime blood pressure, less than 120/70 mmHg for the average nocturnal blood pressure, and less than 135/85 mmHg for the average morning blood pressure. When using rigorous goal thresholds, the target blood pressure (BP) values would be less than 125/75 mmHg for the average 24-hour blood pressure should be below 130/80 mmHg. The average daytime blood pressure should be below 110/65 mmHg, while the average nocturnal blood pressure should be

below 130/80 mmHg. Additionally, the average morning blood pressure should also be below 130/80 mmHg [18].

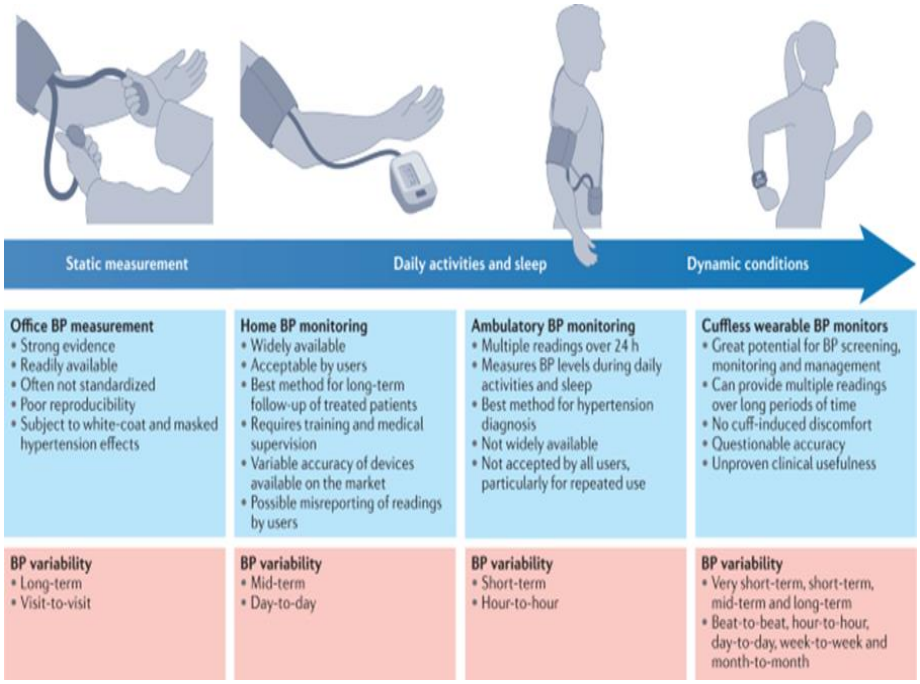

Figure 1: Advantages and disadvantages of classic and novel blood pressure monitoring methods and capacity to capture blood pressure variability. Blood pressure (BP) monitoring methods enable the assessment of BP during static or dynamic conditions over different time windows, and thus can capture different aspects of BP variability [8] .

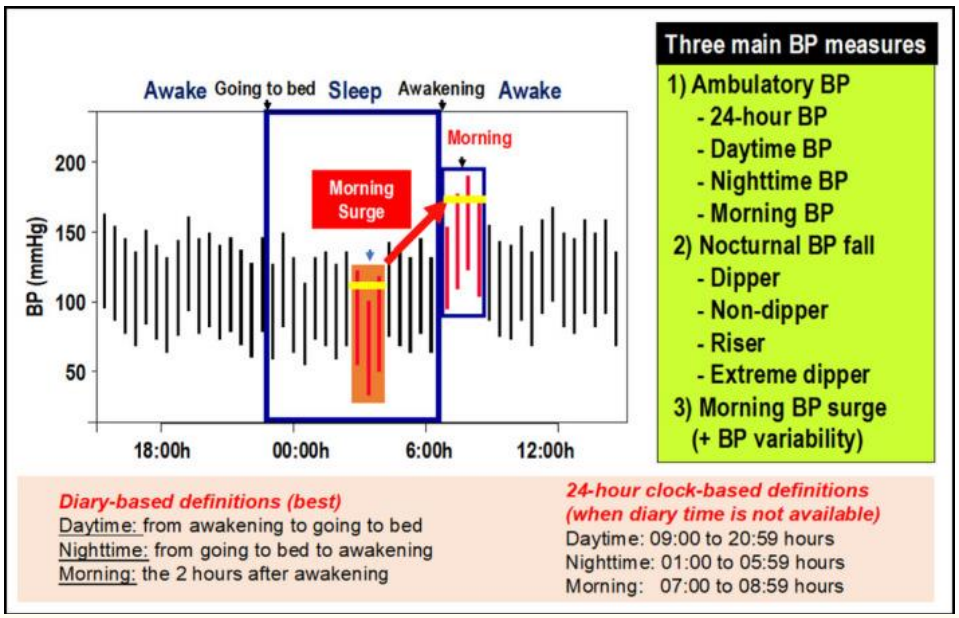

Figure 2: Blood pressure measures determined using ambulatory blood pressure monitoring. BP, blood pressure [18] .

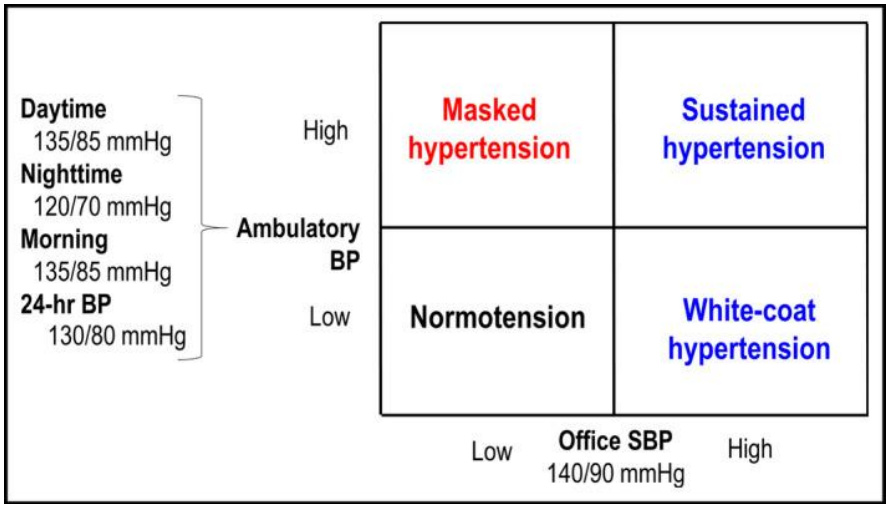

Figure 3: Hypertension classifications based on office and ambulatory blood pressure [21].

DISCUSSION

Ambulatory Blood Pressure Monitoring (ABPM) is essential for the diagnosis and treatment of hypertension and is widely acknowledged as a vital component of effective clinical treatment in this field. Currently, this is the only technique for monitoring blood pressure outside of a medical facility that can offer data on the 24-hour blood pressure pattern encompasses blood pressure variability, nocturnal hypertension, and the morning surge in blood pressure. These factors are all significant indicators of Organ damage that specifically affects the intended area and the likelihood of developing disorders related to the heart and brain. Ambulatory Blood Pressure Monitoring (ABPM) is essential for effectively initiating and overseeing antihypertensive medication. It also enables the assessment regarding the regulation of blood pressure during a 24-hour period. The goal of the offered practice points is to assist physicians in integrating ABPM into their routine practice in order to enhance patient outcomes.

CONFLICT OF INTEREST: The authors declare no conflict of interest.

FINANCIAL DISCLOSURES: This study was not supported by any source of finding.

SOURCES OF FUNDING: No specific grant was obtained for this research from governmental, private, or nonprofit funding organizations.

AUTHOR CONTRIBUTION: Authors contributed equally in the study.

ACKNOWLEDGEMENT

The authors would like to appreciate all the participants and the hospital stuff who contributed to this study.

AUTHOR CONTRIBUTIONS

All the authors carried out this work. RagabAbdelsalam Mahfouz, Tamer Mustafa, Islam Ghanem Ahmed designed and directed the study.

All authors were involved in drafting the article and revising it for important intellectual content and all authors read and approved the final version to be published.

AVAILABILITY OF DATA

Data supporting the results of this article are included within article.

REFERENCES

1- **Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C et al.** 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/ APhA/ASH/ ASPC/ NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American **Heart**

Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2018; 15;71(19):e127-248.

2- Gianfranco Parati,George S.Stergiou, Eamon Dolan,GrzegrozBilo. **Blood pressure variability: clinical relevance and application, J Clinic Hypertens(Greenwich). 2018;20(7):1133-7.**

3- **de la Sierra A.** Blood Pressure Variability as a Risk Factor for Cardiovascular Disease: Which Antihypertensive Agents Are More Effective? J Clin Med. 2023; 12(19), 6167.

4- **Chadachan VM, Ye MT, Tay JC, Subramaniam K, Setia S.** Understanding short-term blood-pressure-variability phenotypes: from concept to clinical practice. Int J Gen Med. 2018;22:241-54.

5- Imaizumi Y, Eguchi K, Murakami T, Saito T, Hoshide S, Kario K. Locomotive syndrome is associated with large blood pressure variability in elderly hypertensives: the Japan Ambulatory Blood Pressure Prospective (JAMP) substudy. J Clin Hypertens. 2017.19(4), pp.388-394.

6- **Rosendorff C, Lackland DT, Allison M, Aronow WS, Black HR, Blumenthal RS et al.** Treatment of hypertension in patients with coronary artery disease. A case-based summary of the 2015 AHA/ACC/ASH scientific statement. Am J Med. 2016; 1;129(4):372-8.

7- **Hassan AK, Abd–El Rahman H, Mohsen K, Dimitry SR.** Impact of in‐hospital blood pressure variability on cardiovascular outcomes in patients with acute coronary syndrome. J Clin Hypertens. 2017 Dec;19(12):1252-9.

8- **Stergiou GS, Kollias A, Protogerou AD.** Evidence on blood pressure measurement methodology and clinical implementation: research agenda for the 21st century. J Am Coll Cardiol. 2017 Aug 1;70(5): 587-9.

9- **Schutte AE, Kollias A, Stergiou GS.** Blood pressure and its variability: classic and novel measurement techniques. Nat Rev Cardiol. 2022 Oct;19(10): 643-54.

10- Picone DS, Schultz MG, Otahal P, Aakhus S, Al-Jumaily AM, Black JA et al. Accuracy of cuff-measured blood pressure: systematic reviews and meta-analyses. J Am Coll Cardiol. **2017;** 70(5), 572–86.

11- Sharman JE, Avolio AP, Baulmann J, Benetos A, Blacher J, Blizzard CL et al. Validation of non-invasive central blood pressure devices: ARTERY Society task force consensus statement on protocol standardization. Eur Heart J. 2017 Oct 1;38(37): 2805-12.

12- Sierra D, Wood M, Kolli S, Felipez LM. Pediatric gastritis, gastropathy, and peptic ulcer disease. Pediatr Rev. 2018 Nov 1;39(11):542-9.

13- Yu S, Chi C, Protogerou AD, Safar ME, Blacher J, Argyris AA et al. 24‐hour aortic blood pressure variability showed a stronger association with carotid damage than 24‐hour brachial blood pressure variability: The SAFAR study. J Clin Hypertens. 2018 Mar;20(3):499-507.

14- Parati G, Torlasco C, Pengo M, Bilo G, Ochoa JE. Blood pressure variability: its relevance for cardiovascular homeostasis and cardiovascular diseases. Hypertens Res . 2020 Jul;43(7):609-20.

15- Sogunuru GP, Kario K, Shin J, Chen CH, Buranakitjaroen P, Chia YC et al. Morning surge in blood pressure and blood pressure variability in Asia: evidence and statement from the HOPE Asia Network. J Clin Hypertens. 2019 Feb;21(2): 324-34.

16- Kario K, Hoshide S, Chia YC, Buranakitjaroen P, Siddique S, Shin J et al. Guidance on ambulatory blood pressure monitoring: a statement from the HOPE Asia Network. J Clin Hypertens. 2021 Mar;23(3):411-21..

17-Kario K, Pickering TG, Umeda Y, Hoshide S, Hoshide Y, Morinari M et al. Morning surge in blood pressure as a predictor of silent and clinical cerebrovascular disease in elderly hypertensives: a prospective study. Circulation. 2003; 18;107(10):1401-6.

18- Kario K, Shimada K. Risers and extreme-dippers of nocturnal blood pressure in hypertension: antihypertensive strategy for nocturnal blood pressure. Clin Exp Hypertens. 2004**;**26**,** 177-89.

19- Cheng HM, Wu CL, Sung SH, Lee JC, Kario K, Chiang CE et al. Prognostic utility of morning blood pressure surge for 20‐year all‐cause and cardiovascular mortalities: results of a community‐based study. J Am Heart Assoc.2017; 9;6(12): e007667.

20-Hsu PF, Cheng HM, Wu CH, Sung SH, Chuang SY, Lakatta EG et al. High short-term blood pressure variability predicts long-term cardiovascular mortality in untreated hypertensives but not in normotensives. Am J Hypertens. 2016 Jul 1; 29(7): 806-13.

21- O'Brien E, Parati G, Stergiou G, Asmar R, Beilin L, Bilo G et al. European Society of Hypertension position paper on ambulatory blood pressure monitoring. J Hypertens. 2013 Sep 1;31(9):1731-68.

22- Grossman E. Ambulatory blood pressure monitoring in the diagnosis and management of hypertension. Diabetes Care. 2013**;** 36 Suppl 2**,** S307-11.

23- Sakakura K, Ishikawa J, Okuno M, Shimada K, Kario K. Exaggerated ambulatory blood pressure variability is associated with cognitive dysfunction in the very elderly and quality of life in the younger elderly.Am J Hypertens, 2007; 20**,** 720-7.

24-Kuwabara M, Harada K, Hishiki Y, Kario K. Validation of two watch‐type wearable blood pressure monitors according to the ANSI/AAMI/ISO81060‐2: 2013 guidelines: Omron HEM‐6410T‐ZM and HEM‐6410T‐ZL. J Clin Hypertens. 2019 ;21(6):853-8.

25- **Mukkamala R, Yavarimanesh M, Natarajan K, Hahn JO, Kyriakoulis KG, Avolio AP et al.** Evaluation of the accuracy of cuffless blood pressure measurement devices: challenges and proposals. Hypertens. 2021;78(5):1161-7.

26- Stergiou GS, Palatini P, Parati G, O'Brien E, Januszewicz A, Lurbe E et al. European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. J hypertens. 2021 Jul 1;39(7):1293-302.

27- Ueshima H. Explanation for the Japanese paradox: prevention of increase in coronary heart disease and reduction in stroke. J Atheroscler Thromb, **2007;** 14**,** 278-86.

Citation:

Mahfouz, R., Elsayed Ali, M., Moustafa, T., Ahmed, I. Practical Importance of Ambulatory Blood Pressure Monitoring. *Zagazig University Medical Journal*, 2024; (3516-): -. doi: 10.21608/zumj.2024.302545.3465