AMBULATORY BLOOD PRESSURE MONITORING
A Thorough Approach to the Diagnosis & Treatment of Uncontrolled Hypertension

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Introduction

Known as the "silent killer", uncontrolled hypertension is the leading cause of heart disease, stroke and death in the United States[1]. Due to the prevalence of the disease, among other reasons, the American Heart Association (AHA) and American College of Cardiology (ACC) *changed their blood pressure classifications* to help raise awareness and begin the diagnosis and treatment of heart disease before it becomes as severe.

The early diagnosis of hypertension alone, however, is not enough to curb the issue. Healthcare providers must work effectively with their patients to control hypertension through proven methods, such as medication and lifestyle changes, to stall or eliminate the prognosis of heart disease and death.

In cases of undiagnosed and/or uncontrolled hypertension, the increased utilization of 24-hour Ambulatory Blood Pressure Monitoring (ABPM) can be a crucial step towards better diagnosis and management of hypertension.

Background

The disease state of hypertension is so prevalent that it now affects over 100 million Americans, nearly 1/2 of the country's population[2]. Of these, only approximately 53% are controlled[3], leaving nearly 40% of hypertensive Americans either undiagnosed or uncontrolled.

To address the growing health risk, in 2017, the ACC and the AHA both updated the blood pressure (BP) guidelines,

lowering thresholds to implement earlier interventions at a BP of 120/80 or higher[4].

As a controllable condition, accurate diagnosis and management of hypertension is critical because it offers great potential to prevent heart attacks and strokes, and it can save patients and providers costs associated with myriad cardiovascular diseases. In fact, the ACC, the AHA[4], and The Million Hearts 2022 initiative prioritized accurately identifying hypertension as the first step in the goal of preventing 1 million heart attacks[5], realistically reducing cardiovascular events by 30%, and all causes of mortality by 25%[4].

Why is it So Hard to Diagnose Hypertension?

In some cases, hypertension may be easy enough for medical professionals to diagnose, but in others, it can pose quite a challenge because of its dynamic nature in relation to constantly changing and underlying influences, both internal and external.

In order to control for variables not normally present during the patient's office visits, studies validate enlisting patients to perform home blood pressure monitoring (HBPM) in their environment for more definitive diagnosis than in-clinic monitoring[6].

Unfortunately, however, there are several BP patterns that are not reflected in office or HBPM because they reflect a snapshot measurement and may not uncover some of the diagnosis patterns below.

Blood Pressure Diagnosis Patterns

As discussed, diagnosing hypertension can be complicated by myriad BP patterns that may not be immediately apparent when the patient presents in the office for a consultation or checkup. In order to ensure proper and timely diagnosis, the full scope of BP patterns must be understood, especially given that many of these patterns are associated with increased complications.

Critical to the understanding of BP patterns is BP load: the percent of abnormally elevated BP measurements, specific to day and night guidelines. BP load is associated with future cardiovascular morbidity and mortality[7] and can be experienced via several types of BP patterns.

BP Pattern: White Coat Hypertension

White Coat Hypertension (WCH) is when a patient's BP is normal outside of the clinic but elevated in the clinic. The name "White Coat Hypertension" was assigned due to the suggestion that being in the presence of a medical provider can be stressful, thus raising BP. If a provider assumes that the patient's BP is always at hypertensive levels when, in fact, they are truly experiencing WCH, it could lead to over-medicating, resulting in potential patient complications second to misdiagnoses.

Best practices suggest that WCH should be ruled out and monitored with suspicion, as there is growing evidence that a portion of patients with WHC have elevations in other stressed-induced situations as well[6,8].

Masked Hypertension

Masked Hypertension is when a patient presents with a normal BP in the clinic, but their BP is elevated outside the clinic. Detection of many masked or hidden hypertension patterns is impossible in the clinic, and, for the most part, by HBPM[6]. A study of 64,000 adults found that masked hypertension was associated with greater risk of all causes of mortality than sustained hypertension or WCH[9].

Stress-Induced Hypertension

Stress-Induced Hypertension is identified when there is variability of BP during the patient's daily life that is not likely to be captured in-clinic or HBPM[6]. An example may be a patient with a stressful job where their BP would consistently be considered hypertensive, even though their levels may return to normal outside of the stress-inducing situation[10].

Morning Hypertension

Morning Hypertension, also known as Morning BP Surge (MBPS), is when average BP is ≥ 130/80 in the first 2 hours after awakening. MBPS is the dynamic phenomenon of BP changes in early morning hours. Morning hypertension is the single most powerful predictor of stroke, cardiovascular events, renal disease, and total mortality[6].

Nocturnal Hypertension

Nocturnal Hypertension is defined as an average BP ≥110/65 mmHg during sleep hours, usually between 1 and 6 AM and when BP does not dip 10-20% during sleep, as is normal. Data supports Nocturnal Hypertension as a better predictor of worsened outcomes than daytime BP, and it is known to correlate with advanced brain, heart, kidney disease and poorer prognosis with increased cardiovascular events, hospitalizations and deaths[6].

Within the Nocturnal Hypertension category are several sub-types:

- With **Sustained Nocturnal Hypertension**, the uncontrolled daytime BP stays elevated during sleep.
- **Nighttime Surge** is a temporary increase in BP. Increased BP variability during sleep can explain nighttime surge and is a unique and critical factor for increased cardiovascular events. Each of the below sub-types are abnormal patterns where BP doesn't decrease, as normal, and it can be higher while sleeping than during awake periods:

Non-Dippers	BP decline of ≤10%
Reverse Dippers (Risers)	BP dips ≤0% compared to waking hours
Extreme Dippers	BP dips abnormally, > 20%[6]

Regardless of the specific sub-type of nocturnal BP patterns a patient is diagnosed with, the increased BP variability during sleep is a unique and critical factor for increased cardiovascular events[6].

Orthostatic Changes

Orthostatic Hypertension occurs when a BP is elevated while a patient is standing. In contrast, Orthostatic Hypotension occurs when a BP drops by 20 mmHg when a patient is standing. Orthostatic Hypotension

often precipitates syncope or falls in the frail or elderly population, which can lead to a host of adverse and potentially life-threatening events[6].

BP Variability

BP Variability (BPV) is diagnosed when there are transient fluctuations in BP that is independent of the mean BP. It is often associated with arterial stiffness and poor cardiovascular outcomes. The instability of BPV is seen in many of the above hypertension patterns, including orthostasis-related position changes[6].

Resistant Hypertension

Resistant Hypertension is an elevated BP in patients who are not controlled after use of a variety of antihypertensive agents. Resistant Hypertension often calls for further evaluation of treatment efficacy[11,6].

The full scope of BP patterns that can affect a diagnosis of hypertension is nuanced before even considering additional internal and external influences. Consequently, traditional in-office and HBPM techniques may not be sufficient to diagnose hypertension.

The Solution: Ambulatory Blood Pressure Monitoring

Due to the complexities of diagnosing hypertension, scores of studies have provided convincing evidence that ambulatory blood pressure monitoring (ABPM) is the recommended technique for diagnosing hypertension because it accounts for many of the internal and external influences that can obfuscate in-office diagnosis, even when supplemented by HBPM.

Additionally, ABPM has been proven to not only better diagnose hypertension, but it may help providers understand the state of BP and better predict cardiovascular, cerebral, and end organ damage better than any other non-invasive BP measuring tool[12]. ABPM also has the unique ability to help providers better diagnose their patients via thorough data analysis of BP load and patterns so appropriate therapeutic treatment plans can be implemented.

- **White Coat Hypertension:** ABPM is so successful in monitoring and diagnosing these cases that CMS began reimbursing ABPM as the gold standard for confirming suspected diagnosis of WCH in 2002[13].

- **Masked Hypertension:** HBPM may occasionally be enough to pick up on hypertensive readings and diagnose Masked Hypertension, yet people often remain inadequately diagnosed and controlled with conventional BP monitoring[15]. Therefore, ABPM is the preferred monitoring tool[4,14] because the automatic monitoring captures BP load at preset intervals during normal activities of daily living without interruption.

- **Stress-Induced Hypertension:** Due to its round-the-clock nature, ABPM is used to identify cycles or periods of elevated BP without interrupting the patterns of the patient, a critical factor in diagnosis of this BP pattern.

- **Morning Hypertension:** ABPM or automated timed monitoring are the only non-invasive tools that can detect Morning Hypertension correctly[6].

- **Nocturnal Hypertension:** ABPM should be the preferred method for identification of nighttime dipping and other nocturnal BP patterns due to its ability to monitor consistently, even while the patient is asleep[6].

- **Orthostatic Hypertension:** Because of its correlation with syncope and falls, ABPM is preferred in diagnosing Orthostatic Hypertension because it provides the most conclusive interpretation of the underlying BP pattern[6].

- **BP Variability:** Due to the nature of BP Variability, fully understanding the BP patterns a patient experiences throughout the course of the day is essential. ABPM is the only method that can achieve such tracking.

- **Resistant Hypertension:** ABPM is valuable in order to better tailor interventions, such as choice of antihypertensives based on their pharmacologic characteristics, timing of dosing, and even integrated specialty support to achieve constant BP control.

Correctly diagnosing the hypertension pattern via ABPM will aid in guiding interventions and treatment toward normalizing BP because it provides clinicians with more data for better choice and timing of medications, and it will reduce variability in measurements. In sum, the improved insights gained from utilizing ABPM in a variety of BP pattern cases can not only help provide the most conclusive interpretation of the underlying BP pattern, but it can minimize preventable

morbidity and mortality due to the tailored treatment plans possible with improved data from ABPM.

Who Should Be Screened with Ambulatory BP Monitoring?

ABPM should be used adjunctly with HBPM for threshold staging for accurate diagnosis and therapeutic management.

Specifically, ABPM should be routinely used for high risk patients as a reference standard to confirm the diagnosis of hypertension[1][2]. High risk patients are those with HBPM ≥ 120/80, a history of cardiovascular event, suspected WCH, suspected nocturnal hypertension (based on comorbidities of sleep apnea, diabetes, chronic kidney disease), and documented organ damage.

Beyond typical high-risk patients, ABPM screening is also recommended for those with a predicted prevalence for developing hypertension of ≥ 16%, based on the *Hypertension Prevalence Estimator Tool*, which is used to predict the percent of the patient population that will develop hypertension[16].

Additionally, age, gender, race, and many comorbidities impact the development of hypertension and should also be considered when considering ABPM screening. With even

one comorbidity, such as obesity or diabetes, the risk for hypertension increases exponentially, as seen in Table 1.

By using ABPM to screen adults who have a certain percentage, say 16% or 20% or more prevalence of developing hypertension, healthcare providers can detect morbid hypertension patterns which otherwise would go undiscovered until advanced disease occurs. Early diagnosis and halting of preventable and irreversible effects of cardiovascular disease through early intervention is possible with ABPM screening.
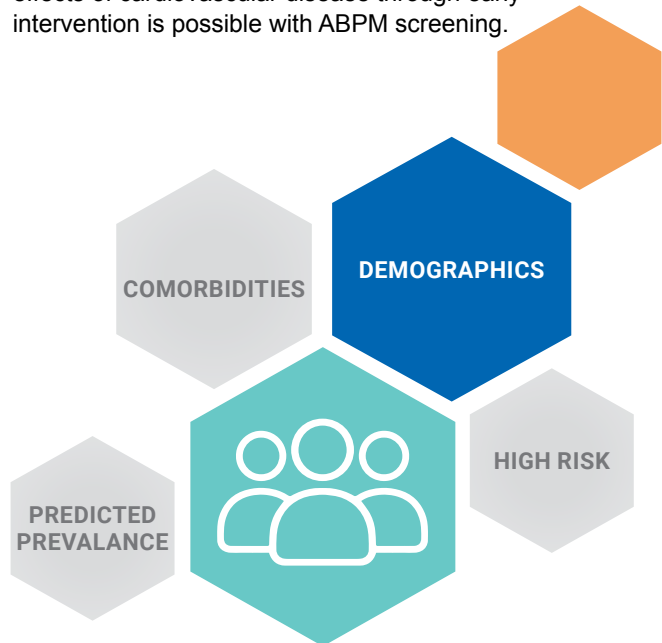

Table 1

Age	CoMorbidity	White			Black			Hispanic		
		Male	Total 6%	Female	Male	Total 9.70%	Female	Male	Total 3.50%	Female
18-44	0	8.40%		3.50%	9.90%		9.30%	5.20%		1.70%
	1	21.10%	16.30%	11.60%	27.80%	22.60%	17.40%	13.90%	10.90%	7.90%
	2	38.20%	37.70%	37.30%	64.80%	58.50%	52.20%	54.60%	39.60%	24.70%
45-64	0	32.30%	29.50%	26.80%	46.10%	46%	45.90%	26.30%	25.10%	23.90%
	1	46.90%	48%	49.20%	60%	63.20%	66.40%	44%	41.10%	38.30%
	2	70.90%	69.10%	67.30%	87%	86.50%	86.10%	64.50%	66%	67.60%
65-74	0	51.90%	53.60%	55.30%	71.50%	70.60%	69.70%	41.10%	53.20%	65.30%
	1	64.20%	66.50%	68.80%	80.90%	84.50%	88%	63.80%	69.80%	75.80%
	2	77%	83.50%	90%	86.10%	89.10%	92.10%	74.50%	79.50%	84.50%

For example, for age 18-44 whites with 0 risk, 1 risk factor, 2 risk factors the prevalence would be 6%, 16.3%, 38%, respectively, of developing hypertension and further disease.

How is ABPM Used, and What Data Will it Provide?

ABPMs can easily be configured by a nurse or medical assistant to monitor the patient's BP at specific preset time periods, such as every 20-30 minutes in the awake hours, and every 60 minutes during the patient's reported anticipated sleep period.

The device should be worn for a minimum of 24 hours so it can capture dynamic readings while the patient is engaged in usual activity, in their home and work environments, and during their sleep periods.

After the 24 hours, the information is downloaded to a computer for review.

The numerous readings provide a plethora of information for clinical decision making as to the person's actual BP load and BP patterns as well as time and date stamped BP and pulse measurements. Additionally, some ABPM devices provide other critical details, such as activity levels, ambient temperature, and barometric pressure, which may aid in diagnosis.

Beyond the basic raw data, the software will provide the clinician helpful tools, such as graphs and diagrams, to highlight the BP loads, sleep percentages, a variety of means (including 24-hour, daytime, and nighttime means), high/low BP measurements, Circadian/Nocturnal rhythms, and irregular pulses.

Altogether, this data paints a picture of not only hypertension but of the patient's unique patterns to elicit proper decision making for clinical management.

The initial target of managing BP should be aimed at evaluating morning BP. After morning control, the next goal would be to measure dynamic BP during the sleep cycles with ABPM and with a goal to keep nocturnal BP controlled at <110/65[6].

What Type of Providers Should Use ABPM?

Given the urgency aimed at lowering BP thresholds, including a focus on early intervention to reverse heart and brain disease progression, morbidity and mortality, ABPM should be used by primary care providers, health departments, obesity and diabetic clinics, wellness centers, managed health groups, nurse or pharmacy hypertensive clinics, along with cardiology and renal specialty clinics.

With its wide range of diagnostic capabilities, efficiency, and ease of use, ABPM should be used early and frequently when hypertension is suspected, given the large number of patients who are going undiagnosed or suffering consequences of uncontrolled hypertension.

ABPM has been recognized by many as a gold standard in diagnosing hypertension[5,6], and as of 2015, the United States Preventative Services Task Force (USPSTF) found it to be the best method to diagnose and confirm hypertension[12]. The CMS also set the standard that ABPM is a valid, useful and cost-effective tool for diagnosing hypertension WCH when it added reimbursements for the procedure in 2002[13].

Beyond medical providers, ABPM is becoming the standard of care among groups like AETNA[17], HealthNet, Kaiser and Columbia University when diagnosing and evaluating BP patterns such as WCH, Masked Hypertension, and more.

How Can ABPM Improve Patient Satisfaction, Increase Survival Rates, and Decrease Cost?

ABPM has been shown to improve the accuracy of a hypertension diagnosis and the clinician's understanding of BP patterns that a patient may experience, but how does it improve outcomes and increase survival, all while decreasing costs?

Improved Patient Satisfaction

Patients experience increased satisfaction when they are given education about how the results are used to guide appropriate lifestyle, nutritional, pharmaceutical, and other medical specialty interventions. Patients who participate by wearing ABPM and who are involved in their self-care are more capable of improving their conditions. Additionally, use of ABPM reduces repetitive office visits for BP monitoring for diagnosis, so patients will have less loss of work and lifestyle changes that accompany physical and psychological limitations of consequences of uncontrolled hypertension.

Increased Survival Rates and Decreased Costs

For the patient, ABPM can help increase survival rates while decreasing their costs because, while hypertension is a

preventable disease, it is a predictor for other, more serious conditions, such as heart attack, stroke, and cardiovascular events, among others. By controlling hypertension, the patient does not experience those health or financial risks of future complications they might have experienced.

For example, a heart attack victim can have between $760,000 and $1 million in healthcare-related costs[18]. It is estimated that ABPM screening in Japan alone will save patients nearly $90 billion dollars over 10-year period. Potentially even more importantly, the same study estimates that during this same time period, ABPM will also save over 10,000 lives and reduce strokes by 60,000[19].

Another study found that the use of ABMP to be cost effective for patients, even if total annual hypertension treatment costs were as little as $300[20] due to reduced heart attacks and strokes and other financial savings, such as the cost of unnecessary treatments due to WCH, repetitive office visits, subsequent costs due to uncontrolled hypertension and resulting conditions, and more.

On the clinician's side, many providers are seeing the benefits of regularly using ABPM in their practices because it is so useful in uncovering hidden hypertensive patterns via *reimbursable procedures* that no other non-invasive modality can detect. Additionally, ABPM data gives way for clinicians to diagnose and make management decisions that they could not without this screening tool. For this reason, ABPM pays for itself by reducing the clinician's time spent diagnosing and managing each potentially-hypertensive case or advanced disease states.

Additionally, some devices even offer the ability to double as an office BP monitor when not in use in an ambulatory capacity, further improving the ROI of the device.

Conclusion

In keeping with the new ACC/AHA guidelines and goals to minimize cardiovascular events by 30%[4], there is growing evidence that ABPM is a key diagnostic tool in assessment and management of hypertension.

Because ABPM can uncover BP patterns that cannot be detected in-office or with HBPM, it should be a go-to tool in any healthcare provider's toolkit when faced with diagnosing and controlling hypertension, which is a proven factor in improving cardiovascular outcomes and limiting the development of patient morbidity or additional conditions.

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