



**IV GUIDELINE FOR AMBULATORY BLOOD  
PRESSURE MONITORING**

**II GUIDELINE FOR HOME BLOOD PRESSURE  
MONITORING**

**IV ABPM / II HBPM**

**Mogi das Cruzes, São Paulo**

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Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Hipertensão  
e Sociedade Brasileira de Nefrologia  
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# Presentation

In light of the growing knowledge provided by Ambulatory and Home Blood Pressure Monitoring (ABPM and HBPM), a review of the Guidelines issued in 2000 is imperative. This “new look” at pressure measurement without the influence of the physician, outside the office, provided by ABPM and HBPM recordings, has greatly improved our understanding of blood pressure behavior, as well as the diagnosis and management of hypertension.

The influence of these methods is so great that we now have, in addition to classical diagnosis of normotension and hypertension, two other diagnostic possibilities: white-coat hypertension and masked hypertension. Such methods are well established in Brazil, and there are a great number of doctors interested in learning them. Thus, Brazilian Societies of Cardiology, Hypertension and Nephrology convened a 28-member expert panel of physicians from many parts of the country, with broad experience in these methods, to draw up this Guideline.

Once more an effort was made to standardize procedures, so that the methods are used judiciously, according to the best available scientific evidence. The purposes of this publication are to improve diagnosis of hypertension and to establish a prognosis for hypertensive patients and anti-hypertensive therapy, using resources offered by ABPM and HBPM.

Organizing Committee

## Degrees of Recommendation and Levels of Evidence set forth in these Guidelines

### Degrees of Recommendation

When applicable, the following classes should be used:

- I - When there is consensus on indication.
- Ia - When there is disagreement regarding indication, but is approved by the majority.
- Ib - When there is disagreement regarding indication, with opinion divided.
- III - When there is consensus on contraindication or when it is not applicable.

### Levels of Evidence

- A: Large, randomized clinical trials and meta-analyses.
- B: Well-designed clinical trials and observational studies.
- C: Case reports and case series.
- D: Publications based on consensus and expert opinion.

# Introduction

## 1. Physiological behavior of the blood pressure (BP) over a 24-hour period

Blood pressure varies due to the interaction of neurohumoral, behavioral and environmental factors (Table I).<sup>1</sup> There is a continuous variation of beat-to-beat blood pressure according to the individual's activity, and this variability has a wider range in hypertensive than in normotensive patients. Values are higher during daytime than those obtained at night-time.

## 2. Blood pressure recording

Blood pressure may be registered by direct, or intra-arterial, and indirect methods, and the most commonly used are:

a) Auscultatory method – use of auscultation to identify the onset and disappearance of Korotkoff's sounds, corresponding to systolic and diastolic blood pressure, respectively.

b) Oscillometric method – use of oscillometry to identify the point of maximum oscillation, which corresponds to the mean blood pressure and determines the systolic and diastolic BP through algorithms.<sup>2</sup>

## 3. Casual blood pressure measurement taken in the physician's office

Casual blood pressure measurement taken in the physician's office, albeit considered a standard procedure for the diagnosis of hypertension and the follow-up of hypertensive patients,<sup>3</sup> is subject to numerous sources of error, especially the influence of the observer and of the environment where pressure is taken. Also, it provides a few readings that do not show good long-term reproducibility (Degree of Recommendation I – Evidence Level A).

## 4. Equipment used for ABPM and HBPM

### 4.1. Validation

ABPM (Ambulatory Blood Pressure Monitoring) and HBPM (Home Blood Pressure Monitoring) devices are considered validated after they have been submitted to validation protocols and have been approved. There are well-defined protocols for validation of the devices,<sup>4</sup> such as that of the *Association for the Advancement of Medical Instrumentation – AAMI*, that classify them as approved or non-approved, or that of the *British Hypertension Society – BHS*, which assigns grades from A to D and considers the device validated when it is graded A or B for systolic and diastolic pressures. Before buying any device, it is important to check whether it is validated by looking at:

[www.eshonline.org](http://www.eshonline.org)

[www.hyp.ac.uk/bhs/bp\\_monitors/automatic.htm](http://www.hyp.ac.uk/bhs/bp_monitors/automatic.htm)

[www.dableducational.com/sphygmomanometers/  
devices\\_3\\_abpm.html](http://www.dableducational.com/sphygmomanometers/devices_3_abpm.html)

(Degree of Recommendation I – Evidence Level B).

### 4.2. Calibration

Calibration must be performed by the manufacturer or its representative at least once a year or according to manufacturer's specifications (Degree of Recommendation I – Evidence Level D). Calibration should also be performed whenever readings differ by more than 5 mmHg from those obtained with a calibrated mercury-column device, through a Y-connector, a procedure that must be done at least every 6 months. (Degree of Recommendation IIa – Evidence Level D).

### 4.3. Cuffs

Cuff size should be appropriate for the upper arm circumference (Table 2) and supplied by the original instrument manufacturer.<sup>3</sup> (Degree of Recommendation I – Evidence Level B). The use of correction charts is not recommended, and neither is placement of the cuff on the forearm (Degree of Recommendation IIa – Evidence Level B).

## 5. White-coat phenomenon: white-coat effect, hypertension and normotension.

Blood pressure values obtained in the office setting may be higher, similar or lower than those measured during daytime by ABPM or HBPM. Based on these differences, patients can be classified into four different categories (Figure 1): normotension, hypertension, white-coat hypertension (isolated office hypertension)<sup>5</sup> and masked hypertension (white-coat normotension).<sup>6</sup>

Normotension is characterized by normal blood pressure values measured in the office (lower than 140/90 mmHg) and by 24-

**Table 1. Blood pressure variations (mmHg), according to different situations and activities**

Activities	Systolic Pressure	Diastolic Pressure
Meetings	+ 20.2	+ 15.0
Working	+ 16.0	+ 13.0
Walking	+ 12.0	+ 5.5
Putting on clothes	+ 11.5	+ 9.7
House chores	+ 10.7	+ 6.7
Making phone calls	+ 9.5	+ 7.2
Talking	+ 6.7	+ 6.7
Watching TV	+ 0.3	+ 1.1
Resting	0	0
Sleeping	- 10.0	- 7.6

**Table II. Acceptable dimensions of the rubber bladder for different sizes of arms<sup>3</sup>**

Cuff denomination	Arm circumference (cm)	Cuff width (cm)	Bladder length (cm)
Infant	6-15	5	15
Child	16-21	8	21
Small adult	22-26	10	24
Adult	27-34	13	30
Large adult	35-44	16	38
Thigh	45-52	20	42

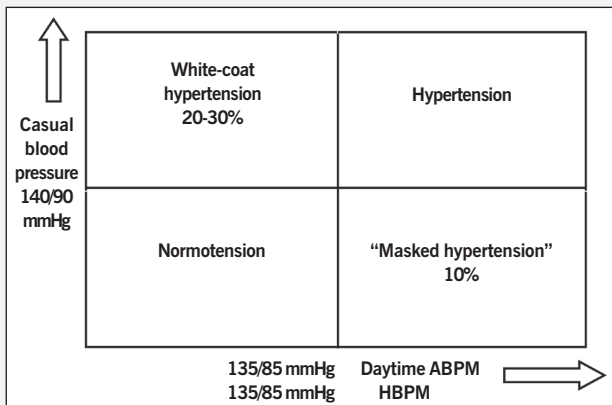


Fig. 1 - Diagnostic possibilities according to casual blood pressure measurements and by ABPM during daytime or HBPM.<sup>57-68</sup>

hour ABPM (equal to or lower than 130/80 mmHg) or by HBPM (equal to or lower than 135/85 mmHg), while hypertension is characterized by abnormal blood pressure values measured in the office (equal to or higher than 140/90 mmHg) and by 24-hour ABPM (higher than 130/80 mmHg) or by HBPM (higher 135/85 mmHg).

White-coat effect is defined as the value obtained by the difference between the blood pressure measured in the office and by ABPM during daytime or HBPM, without any change in the diagnosis of normotension or hypertension. The white-coat effect is considered relevant when the difference is higher than 20 mmHg and 10 mmHg for systolic pressure and diastolic pressure, respectively.<sup>7</sup>

White-coat hypertension occurs when abnormal values are obtained at the physician's office (equal to or higher than 140/90 mmHg) and normal values are obtained by daytime ABPM (equal to or lower than 135/85 mmHg) or by HBPM (equal to or lower than 135/85 mmHg). It is important to note that, under such circumstances, the diagnosis changes from normotension outside the office to hypertension in the office.

Masked hypertension occurs when blood pressure values are normal in the office setting (lower than 140/90 mmHg) and ab-

normal with daytime ABPM (higher than 135/85 mmHg) or HBPM (higher than 135/85 mmHg). Under these circumstances, the diagnosis also changes from hypertension outside the office to normotension in the office.

### 5.1. Clinical significance and prognosis of white-coat hypertension

Aspects that guide diagnostic research in this case are: young or elderly, female, report of normal readings out of the office and hypertension stage I with no target organ damage. Some studies suggest that white-coat hypertension represents an intermediate cardiovascular risk between normotension and hypertension, howbeit closer to the risk of normotense patients<sup>8, 9, 10</sup> (Degree of Recommendation IIb – Evidence Level B). Even though there is no evidence of benefits from interventions in this group, patients must be considered within the context of global cardiovascular risk and remain in clinical follow-up.

### 5.2. Clinical significance and prognosis of "masked" hypertension (white-coat normotension)

Aspects that guide diagnostic research in this case are: youngsters with normal or borderline casual blood pressure and left ventricle hypertrophy; hypertensive parents; reports of occasionally high readings outside the office and high cardiovascular risk.<sup>11</sup> Some studies suggest that target organ damages are more prevalent among these patients than among normotense patients, but this is controversial.<sup>12</sup>

## 6. Establishing public or private ABPM or HBPM

Establishing public or private ABPM or HBPM medical services in offices, outpatient clinics or diagnostic centers requires trained staff and compliance with protocols recommended by Brazilian Guidelines. A physician shall be responsible for the service provided, preferably with specific knowledge on hypertension, ABPM and HBPM.

# IV Guideline for Ambulatory Blood Pressure Monitoring

## 1. Definition

Ambulatory Blood Pressure Monitoring (ABPM) is a method of recording indirect and intermittent blood pressure readings over a 24-hour period while the patient performs his/her usual activities of daily life, including waking and sleeping hours. The term “holter pressure” should be avoided.

## 2. Indications, advantages and limitations of ABPM

ABPM allows a large number of blood pressure readings to be recorded, usually over 24 hours, providing BP variations profile during daytime and night-time. Today, evidence shows that the variables obtained by ABPM are better predictors of primary results, that is to say, major cardiovascular events, including myocardial infarction and stroke, when compared to casual office blood pressure measurements.<sup>13, 14, 15, 16, 17</sup> Moreover, it offers certain potential advantages over casual office blood pressure measurement, such as, attenuation of observer effect on blood pressure; elimination of record bias; the obtaining of values closer to the patient’s usual blood pressure; the possibility of evaluating the effect of blood pressure during night sleep and early morning surge; and evaluation of therapeutic response during the 24-hour period. ABPM is useful for evaluating some clinical conditions (Table 3), and both its advantages (Table 4) and limitations should be considered (Table 5).

## 3. Equipment

The most commonly used devices currently are those based on the oscillometric method with a cuff attached to the upper arm. Wrist devices should not be used for 24-hour measurements, since they have not been validated (Degree of Recommendation III – Evidence Level D).

## 4. Protocol for the examination and instructions to patients

The device should be programmed to take BP at least every 30 minutes, in such a way that, at the end of the 24-hour period, a minimum of 16 valid daytime and 8 valid nighttime readings have been taken (Degree of Recommendation I – Evidence Level B)<sup>14, 18</sup>. At the physician’s discretion, in view of a possible loss of measurements or for the purpose of evaluating symptoms, a larger number of readings may be recommended. Also, depending on the goal of the test, for example, to evaluate

a sub-period of the 24 hours, a number of readings below the one advocated may be accepted.

The monitor may be installed by a trained nurse or technician, who may instruct the patients. Ideally, a 24-hour phone number should be provided for clarification of doubts and resolution of any problems that may arise, including excessive discomfort, allergic reactions, and edema. Scheduling guidelines (Table 6), installation protocol (Table 7), guidelines protocol for appropriate diary completion (Table 8) and removal protocol (Table 9) are fundamental to the quality of the examination.

**Table 3 - Primary indications for ABPM**

- Suspected White-coat Hypertension (Degree of Recommendation I – Evidence Level B).
- Evaluation of the efficacy of anti-hypertensive therapy (Degree of Recommendation IIa - Evidence Level B):
  - a) when casual blood pressure remains elevated despite optimization of anti-hypertensive treatment for diagnosis of Resistant Hypertension (Degree of Recommendation IIa – Evidence Level B) or White-coat Effect (Degree of Recommendation IIa – Evidence Level B).
  - b) when casual blood pressure is under control and there is evidence of persistence (Degree of Recommendation IIb – Evidence Level B) or progression (Degree of Recommendation I – Evidence Level B) of target organ damage.
- Evaluation of normotensive patients with target organ damage (Degree of Recommendation IIb - Evidence Level D)
- Evaluation of symptoms, especially hypotension (Degree of Recommendation I - Evidence Level D)

**Table 4 - Main advantages of ABPM**

- Taking of multiple measurements within the 24-hour period;
- Evaluation of blood pressure during daily activities;
- Evaluation of blood pressure during sleep;
- Evaluation of the circadian pattern of blood pressure;
- Evaluation of the means, loads, and variabilities of blood pressure;
- Identification of the “alarm” reaction;
- Attenuation of the placebo effect;
- Evaluation of anti-hypertensive effect in the 24-hour period;
- Possibility of risk stratification.

**Table 5 - Main limitations of ABPM (Degree of Recommendation I - Evidence Level D)**

- Arms that do not allow appropriate adjustment of the cuff.
- Exceedingly high systolic blood pressure.
- Clinical conditions associated to movement disorders (Parkinsonism, etc).
- Exceedingly irregular pulses (atrial fibrillation and flutter).
- Auscultatory gap when the auscultatory method is used.

**Table 6 - Scheduling Instructions**

- Perform ABPM preferably on a day of normal activities.
- Follow the doctor’s assistant’s instructions on chronic-use drugs.
- Avoid exercising for 24 hours before the examination.
- Bring a list of drugs with the times and dosages prescribed.
- Do not take showers during the examination.
- Inform that the monitor can be worn around the waist attached to a belt.

**Table 7 - Installation protocol – Part 1**

- Explain the method and recommend that daily activities be maintained during the examination.
- Recommend compliance with medical orientations and medication regimen.
- Measure weight and height, especially of children and adolescents.
- Measure arm circumference and select a cuff of appropriate width and length.
- Measure blood pressure in the sitting position after a 5-minutes rest in both arms before the installation of the device with sphygmomanometer, as well as in standing position, especially in elderly patients.
- Attach cuff to the non-dominant arm when the difference of systolic blood pressure is below 10 mmHg. When it is equal to or higher than 10 mmHg, attach the cuff to the arm with higher systolic pressure.
- Place cuff 2 or 3 cm above the cubital fossa, following the specifications of the device used.
- Program the monitor, following the recommendations given in item 4. The awake and asleep periods should be defined from patient's information.
- After installing the equipment, compare the measurement obtained by ABPM monitor to the measurement obtained previously with the sphygmomanometer.
- Take at least two measurements before discharging the patient.

**Table 7 - Installation protocol – Part 2  
Recommendations to the patient**

- Explain that no showers can be taken throughout the examination.
- Explain how to deflate the cuff manually and how to take a manual measurement in case of need or in the presence of symptoms.
- Keep the arm still and hanging relaxed along the body.
- Recommend that the monitor not be disconnected from the cuff and that the cuff not be changed from one arm to the other.
- Alert regarding a possible need to adjust the cuff during the day and to reposition the monitor during the sleeping period.
- Encourage the patient to keep up his/her daily activities during the examination.
- Avoid lying down over the cuffed arm.
- Explain the protocol for filling out the diary, emphasizing its relevance.

**Table 8 - Protocol for diary completion**

- Specify the activities performed during the 24 hours: at work, at home, at school, both physical and resting activities.
- Take notes of meal times and if consumption of alcohol, coffee and cigarette was within the usual amount or in excess.
- Take notes of the name, dosage and times medications were taken during the monitoring period.
- Take notes of the time spent commuting.
- Report stressing events that may occur.
- Report the presence of symptoms, preferably including time of onset and disappearance and the action taken for their resolution.
- Take notes of retiring and rising times, including during the day (nap) and the quality of sleep (good, satisfactory, unsatisfactory or interrupted)

## 5. Repeated ABPM evaluation during follow-up period

There is no consensus recommendation regarding periodicity of ABPM examinations. Nevertheless, it is suggested that:

a) ABPM test be repeated on an annual basis for patients with white-coat hypertension, as these may become hypertensive (Degree of Recommendation IIb – Evidence Level D)<sup>19</sup>.

b) Blood pressure be evaluated in hypertensive patients under treatment with relevant white-coat effect, usually defined as the difference between casual blood pressure and mean awake ambulatory blood pressure equal to or higher than 20 mmHg for systolic pressure and 10 mmHg for diastolic pressure (Degree of Recommendation IIb – Evidence Level D)<sup>20</sup>.

**Table 9. Protocol for removal of the device**

- Check the diary with the patient, especially medication times, duration and quality of sleep and report or “incidental events”.
- Make a subjective analysis on the quality of the activities performed during the monitoring period (if the patient conducted his usual daily activities; if the activities were restricted because of the discomfort caused by inflations, among others). These facts should be taken into account in the production and interpretation of the report.
- Check the number of valid readings and the possible need to repeat the test, and inform this to the patient.

## 6. Costs of the examination

The costs should not be considered a limitation for the test, because therapeutic and diagnostic approaches based on ABPM do not necessarily raise the overall cost of treatment, since ABPM may allow identification of patients with white-coat hypertension, decrease prescription of anti-hypertensive drugs and reduce the number of visits to the doctor<sup>21</sup>. (Degree of Recommendation I – Evidence Level B).

## 7. Reproducibility of the Method

ABPM examination demonstrates good reproducibility (Degree of Recommendation I – Evidence Level C). Values of systolic, diastolic, and mean blood pressure, as well as heart rate obtained in a 24-hour period, daytime and night-time, demonstrate similar results in consecutive tests performed within a short-time interval<sup>22-23</sup>. Blood pressure variation between daytime BP and night-time BP also shows good reproducibility, when considered as a continuous variable. Conversely, reproducibility of conditions with and without nocturnal dip has been debated in the literature, because 30% to 50% of the individuals are likely to change category in subsequent tests<sup>24</sup>. Variation phenomenon between awake and asleep BP, therefore, should be considered in its percentage and absolute value in mmHg.

## 8. Normal values for blood pressure obtained by ABPM

### 8.1. Mean blood pressures

Among all parameters derived from ABPM, mean blood pressures are the best data to be analyzed, because they have higher indices of correlation with diagnosis, target organ damage, and cardiovascular prognosis, and are the only ones associated with mortality<sup>25</sup>. Analysis of 24-hour periods, waking and sleeping hours, is critical for evaluation of mean blood pressures (Degree of Recommendation IIa – Evidence Level B).

As in the case of casual blood pressure measurement, normality criteria for pressure values obtained by ABPM are arbitrary. Table 10 shows values considered abnormal for ABPM (Degree of Recommendation IIb – Evidence Level B). For the adult population, abnormal readings represent only a guide to interpretation of the test. Lower pressure levels may be clinically significant in patients with multiple risk factors and/or associated diseases (Degree of



**Table 10. Threshold for abnormal blood pressure values within the 24-hour periods, wake and sleep**

	Mean Abnormal Blood Pressure (mm Hg)	
	Systolic	Diastolic
24 hours	>130	>80
Wake	>135	>85
Sleep	>120	>70

Recommendation IIb – Evidence Level D). It is important to emphasize that no longitudinal studies have been conducted with ABPM within the Brazilian population. Mean systolic and diastolic values obtained by ABPM during daytime are usually lower than those obtained by casual measurements<sup>14, 26-28</sup>.

Clinical relevance of specific periods, such as the first hours after waking and during the afternoon nap, is yet to be established. In hypertensive elderly Japanese, it was demonstrated that the rapid surge in blood pressure during the first two hours after waking is associated with a higher incidence of stroke (Degree of Recommendation IIb, Evidence Level B)<sup>29</sup>.

## 8.2. Blood pressure loads and areas under the curve (AUC)

Although the percentage of values above a fixed threshold was defined since 1988, this criterion has been widely criticized. One of the most consistent criticisms refers to the fact that the same value of blood pressure loads may mean different behaviors estimated by mean blood pressures.

Despite the fact that a direct relationship between load values, especially above 50%, and damage to target organs has been documented, the trend observed in the most recent guidelines for ABPM is to not consider blood pressure loads in clinical interpretation (Degree of Recommendation IIa, Evidence Level B)<sup>20,31</sup>.

Even though some suggestions have been made regarding the use of calculations of the areas under the curve for evaluating pressure behavior, there is a need for studies on their application (Degree of Recommendation IIa, Evidence Level B).

## 8.3. Mean blood pressure, pulse pressure and variability

Mean blood pressure is provided by the examination, its applicability being restricted to clinical research.

In spite of the great clinical relevance placed on pulse pressure, based on casual measurements and with strong evidence of prognostic implications, so far there are no criteria for the interpretation of this parameter by ABPM. A study conducted with a limited number of patients, however, shows that pulse pressure evaluated by ABPM may also have prognostic implications (Degree of Recommendation IIa, Evidence Level B)<sup>8</sup>.

It is known that blood pressure variability (BPV) has a strong prognostic correlation with cardiovascular events and the development of target organ damage. Nevertheless, only through continuous blood pressure recording (beat-to-beat), can variability be appropriately evaluated, unlike 24-hour BP recordings. Standard

deviation of mean blood pressure obtained by ABPM should not be used as indicative of blood pressure variability, because as yet there are no normality criteria for its interpretation (Degree of Recommendation III – Evidence Level D).

## 8.4. Heart rate

Despite recording heart rates, ABPM devices are not appropriate for measuring this parameter; thus, they should not be considered, except in the cases of devices that can register 24-hour ECG simultaneously (Degree of Recommendation III – Evidence Level D.)

## 8.5. Day-night differences in blood pressure

The definition of awake and asleep periods relies heavily on the accurate recording of times when the individual undergoing the test slept and woke up. This data should be clearly recorded in the activities diary. The quality of sleep reported by the patient throughout the examination should be taken into account in interpreting wake-sleep pressure variations (Degree of Recommendation I – Evidence Level C).

Usually, there is a decrease, or dip, in systolic and diastolic BP during sleep, compared to the waking period. It was noted that a decrease of less than 10% in hypertensive individuals is related to a worsening in the cardiovascular prognosis<sup>32</sup>. The clinical significance of lack of blood pressure decrease during sleep also was confirmed in normotensive patients<sup>33</sup>. Kario *et al.*<sup>34</sup> showed that, in elderly hypertensive patients with nocturnal dips greater than 20%, there was an increase in cardiovascular risk, especially of stroke.

It should be remembered that either a reversal of physiological behavior in awake and asleep pressure or a lack of nocturnal dip might be related to certain circumstances, such as sleep disorder caused by the examination, inappropriate blood pressure control in treated patients and, in some cases, secondary hypertension, sleep apnea, dysautonomia, and use of some drugs such as cyclosporine.

Day-night blood pressure variation can be expressed in absolute values (mean awake BP – mean asleep BP); day/night BP ratio (mean asleep BP/mean awake BP x 100); or in percentage values (mean awake BP - mean asleep BP/mean awake BP x 100. Table 11 shows a classification of the percentage variation of systolic and diastolic awake-asleep blood pressure, according to Ohkubo *et al.*<sup>25</sup> (Degree of Recommendation IIa – Evidence Level B). If there is a dip in systolic and diastolic blood pressures that belong to different classifications, they should be described separately in the report (Degree of Recommendation I – Evidence Level D).

**Table 11. Classification of wake-sleep blood pressure variation<sup>24</sup>**

Blood pressure dip during sleep (%) for systolic and diastolic	
Present	≥10
Absent	≤0
Attenuated	> 0 e < 10

## 9. ABPM in special situations and populations

### 9.1. Children and adolescents

In children and adolescents, ABPM is indicated for suspected white-coat hypertension<sup>35</sup>, evaluation and follow-up of primary and secondary hypertension or conditions with associated risk of arterial hypertension, such as diabetes mellitus<sup>36-37</sup>, chronic pyelonephritis<sup>38</sup>, chronic renal failure<sup>39-40</sup>, and autosomal dominant polycystic kidney disease<sup>41</sup>, because it shows better correlation with the development of target organ damages than office blood pressure measurement (Degree of Recommendation IIa – Evidence Level C).

Only a few ABPM devices have been validated for use in children. Applicability, however, is promising, and there have been reports of good precision and reproducibility<sup>42</sup>. The success percentage in obtaining measurements increases with age<sup>42-43</sup>. The primary limitation to its use in children and adolescents is the lack of normative pediatric values. Values were defined using, as a reference for awake blood pressure, the 95th percentile of the tables of casual blood pressure measurement for age, sex and height, and, during sleep, normal values 10% below these<sup>44</sup>. When the value corresponding to the 95th percentile is greater than the limits of normality established for the adult population, the values applicable to adults should be considered for the reports (Degree of Recommendation IIb – Evidence Level D). Just as in the case of adults, there is a tendency to consider the 90th percentile as limit of normality, especially in the presence of comorbidities. The relevance of and normality criteria for pressure loads and dip in blood pressure during sleep in children and adolescents have not yet been established.<sup>45</sup>

### 9.2. Elderly patients

ABPM can provide valuable clinical support for suspected orthostatic, postprandial, drug-related and situational arterial hypotension, as well as for evaluation of patients with dysautonomia and syncope (Degree of Recommendation IIa – Evidence Level D)<sup>26</sup>. In elderly individuals with isolated systolic hypertension, ABPM is useful to rule out white-coat effect (Degree of Recommendation IIa – Evidence Level A)<sup>46</sup>. Some limitations must be emphasized in this age group. Age-related arterial stiffening underestimates blood pressure measurement obtained by the oscillometric method and thus, ABPM is subject to errors in the presence of pseudo-hypertension<sup>47</sup>. The presence of auscultatory gap, commonly seen at an elderly age, might compromise the evaluation by the auscultatory method<sup>48</sup>. The same normality values applied to younger adults are accepted for elderly individuals (Degree of Recommendation I – Evidence Level D)<sup>26</sup>. Elderly individuals with high blood pressure variability, however, often sleep during the day, and suffer from sleep disorders. Thus, special care should be taken when registering activities in the diary, emphasizing these aspects, which must be taken into account during ABPM evaluation. The use of asleep and awake preset periods is not advisable. The drawback of nocturnal dip, increased

pulse pressure, and early morning surge in blood pressure, common among the elderly, are related to increased cardiovascular risk<sup>21,46,49</sup>.

### 9.3. Pregnant women

Ambulatory blood pressure monitoring during pregnancy has been used to identify white-coat hypertension, whose prevalence is similar in both pregnant and nonpregnant women. Its identification is critical, however, during pregnancy to prevent unnecessary treatment that could be potentially harmful to the fetus (Degree of Recommendation IIa – Evidence Level B)<sup>51-52</sup>. Diagnosis of preeclampsia by ABPM, suggested by sleep-wake cycle alteration is still controversial, since a number of cases with confirmed diagnosis do not show this alteration<sup>53-54</sup>. Nevertheless, when found, it must be taken into account. The possibility of anticipating the development of preeclampsia by ABPM has not been confirmed<sup>55</sup>. ABPM reference parameters during pregnancy concur with the findings of a linear decrease in blood pressure during the first half of pregnancy measured by casual blood pressure, followed by a continuous increase until delivery. Table 12 shows the mean values observed in each trimester of pregnancy (Degree of Recommendation IIa – Evidence Level C)<sup>56</sup>.

### 9.4. Diabetes mellitus

ABPM in diagnosed diabetics may contribute to clarify symptoms related to hypotension secondary to autonomic neuropathy (syncope, dizziness, sweating among others), thus aiding differential diagnosis with hypoglycemia. In addition, it can help in the identification of patients with masked hypertension.<sup>26</sup> Although the change in wake-sleep pattern seems to be associated with the development of microalbuminuria and increased cardiovascular risk<sup>26,57-59</sup>, these findings are still debatable (Degree of Recommendation IIa – Evidence Level C). The target value for controlling casual blood pressure in the hypertensive diabetic patient is lower than that for hypertensives in general. This value for ABPM, however, has not yet been established, and this must be taken into account in the report.

### 9.5. Obesity

Indications for the use of ABPM in obese patients are the same as those for the general population (Degree of Recommendation I – Evidence Level D). As the buildup of fat tissue may preclude blood pressure measurement by the auscultatory method, the oscillometric is preferred.<sup>26</sup> Use of the appropriate cuff for arm circumference

Table 12 - ABPM values (mmHg) during the trimesters of pregnancy<sup>55</sup>

	Gestational Weeks			
	9-16	18-24	26-32	33-40
Wake				
Systolic Pressure	115±8	115±8	116±9	119±9
Diastolic Pressure	70±7	69±6	70±7	74±7
Sleep				
Systolic Pressure	100±7	99±8	101±8	108±8
Diastolic Pressure	55±5	54±6	55±6	58±7



cannot be over-stressed. In obese patients with arm circumference above 20,5 inches or short arms, the examination is contraindicated, because ABPM devices do not have appropriate cuffs (Degree of Recommendation III – Evidence Level D)<sup>27</sup>.

It should also be emphasized that in obese patients, particularly those with visceral fat distribution, an increased frequency of alert reactions to casual blood pressure measurement has been reported, causing a higher prevalence of white-coat phenomenon.<sup>60-62</sup>

## 9.6. Renal failure

The target value for controlling casual blood pressure in hypertensive patients with renal disease is lower than that for hypertensives in general. This value for ABPM, however, has not yet been established, and this must be taken into account in the report. In hemodialysis patients, a 24-hour ABPM may identify changes in wake-sleep patterns and detect hypotension episodes, but do not provide an evaluation of blood pressure along the dialysis cycle<sup>63</sup>. Thus, the use of a 44-hour ABPM (installed after a hemodialysis session and removed just before the next session) allows a more complete evaluation. When performed during 24 hours, the analysis of the report should consider whether the test was conducted on the day of the dialysis session or between sessions. In this population, the cuff cannot be placed on the arm of patients with arteriovenous fistula. Blood pressure pattern behavior during sleep do not change in most patients submitted to continuous ambulatory peritoneal dialysis (CAPD)<sup>63</sup>.

## 9.7. Heart failure

ABPM may be indicated to optimize treatment in patients with heart failure whose symptoms are related to blood pressure changes, such as paroxysmal nocturnal dyspnea or diastolic heart failure. Likewise, it can be useful for orienting therapy of patients with symptoms caused by hypotension. Changes in wake-sleep pattern have been associated to the severity of systolic dysfunction (Degree of Recommendation IIb – Evidence Level C).<sup>64, 65</sup>

## 9.8. Heart transplant

In heart transplant patients, ABPM may be used to improve blood pressure control and, thus, minimize cardiac and renal complications related to the use of cyclosporine. These patients sustain loss of modulation of blood pressure and heart rate during sleep, with greater blood pressure variability in the waking period and wake-sleep pattern change (Degree of Recommendation IIb – Evidence Level C)<sup>66</sup>.

## 9.9. Sleep apnea syndrome

In patients with clinical signs suggestive of sleep apnea, a change in wake-sleep pattern at ABPM may reinforce this diagnosis<sup>67</sup>.

## 9.10. Secondary hypertension

In curable forms of hypertension, once cured, some ABPM variables may reveal changes early, suggesting possible recurrence<sup>68</sup>.

## 9.11. Physical exercise and ABPM

Physical exercise should be avoided during ABPM tests, because continuous muscle contraction produces both inaccurate readings and loss of measurements. Indeed, blood pressure obtained during exercise has been validated only for the standard auscultatory method (Degree of Recommendation IIa – Evidence Level B)<sup>69</sup>.

Aerobics (dynamic exercises involving large muscle groups that are cyclically contracted, at moderate intensity and over a prolonged time – more than 30 minutes – such as, walking, running, cycling, swimming, dancing, etc.), causes post-exercise reduction in blood pressure that lasts up to 16 hours, reducing mean 24-hour post-exercise blood pressure. Such effect is greater in individuals with higher blood pressure levels<sup>70, 71, 72</sup>. Therefore, exercise should be avoided on the day prior to the examination, especially by individuals who do not practice regularly, or prior exercise should be taken into account when producing the ABPM report (Degree of Recommendation IIa – Evidence Level B).

The recognized blood pressure reduction promoted by regular exercising on casual blood pressure<sup>73</sup> has not yet been conclusively established at ABPM<sup>71</sup>.

Little is known about acute and chronic effects of resistive exercise (weight training) on ABPM<sup>74</sup>.

## 10. The role of ABPM on prognostic evaluation of hypertensive patients

Blood pressure values obtained by ABPM are more strongly correlated with target organ damages, morbidity, and mortality than casual blood pressure measurements<sup>13-17</sup>.

Mean 24-hour systolic and diastolic BP values, daytime and night-time, shows a positive correlation with target organ damages, such as left ventricle hypertrophy, ischemic brain lesions, and microalbuminuria<sup>47</sup>.

In elderly patients evaluated in the Syst-Eur Study, the variable that showed the best correlation with major cardiovascular events, such as stroke, acute myocardial infarction and death, was sleep systolic BP, followed by 24-hour systolic BP and wake systolic BP<sup>15, 25</sup>.

Regarding prognosis associated to nocturnal dip, it is known that the magnitude of blood pressure dipping during sleep shows a reverse correlation with cardiovascular outcomes. Thus, for every 5% increment in systolic or diastolic night-day BP ratio, there is a 20% increase in cardiovascular mortality, even in individuals with normal mean blood pressure values obtained by ABPM<sup>7, 75</sup>.

As for blood pressure variability, which is obtained by the standard deviation of pressure values yielded by ABPM, there is evidence of association with target organ damages<sup>76</sup>.

On the other hand, the morning surge in blood pressure, calculated by the difference between morning systolic BP (mean blood pressures during the 2 hours after awakening) and the lowest sleep systolic BP (mean lowest reading and the readings immediately before and after), has been demonstrating negative implications on cardiovascular outcomes. In elderly patients, it was found that a morning surge above 55 mmHg was associated to a greater prevalence of ischemic stroke (Figure 2)<sup>29</sup>.

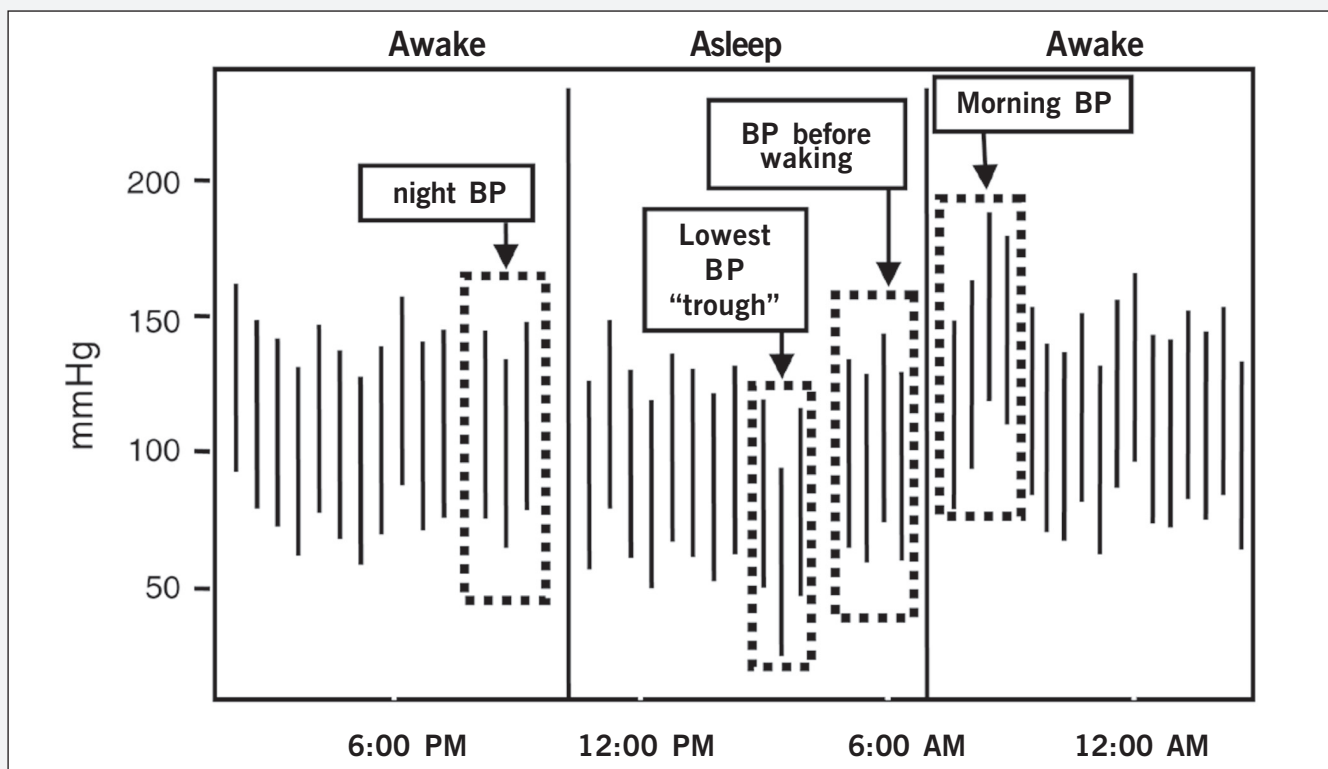


Fig. 2 - Parameters used for calculation of morning surge in blood pressure.<sup>21</sup>

Pulse pressure, obtained with ABPM and calculated by the difference between mean 24-hour systolic and diastolic blood pressures, was also found to be predictive of events. Values exceeding 53 mmHg are related to an almost five-fold increase in cardiovascular events<sup>46</sup>. Thus, it has been suggested that daytime BP, pul-

se BP and the presence of dip during sleep (Figure 3) be used for an additional cardiovascular stratification risk of hypertensive patients diagnosed by casual in-office measurements and left untreated<sup>8</sup>. Nevertheless, these variables are not indicated as a guide to therapy.

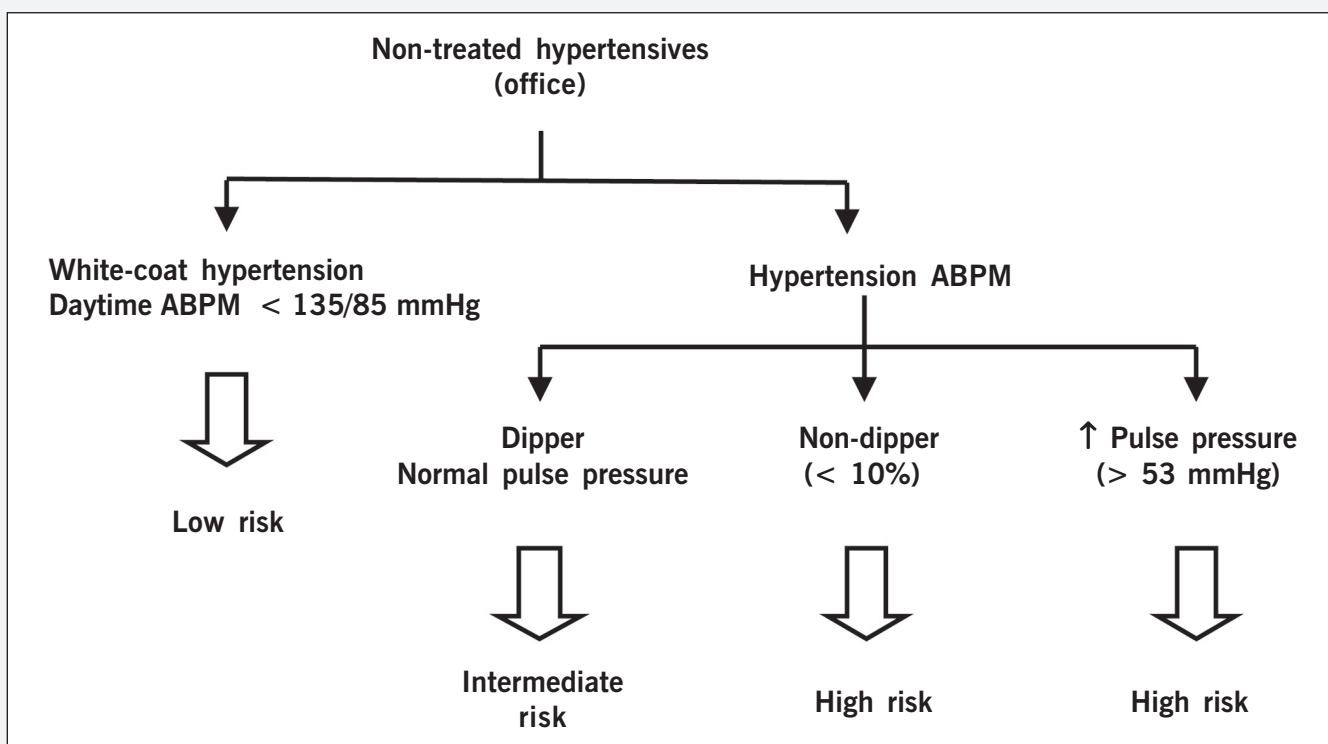


Fig. 3 - Cardiovascular risk stratification based on ABPM.<sup>5</sup>



## 11. Production of reports and interpretation of results

The results are considered valid for an appropriate interpretation when the following aspects are observed: minimum duration of the test – 21 hours; number of valid readings – 16 daytime readings and 8 night-time readings (Degree of Recommendation I – Evidence Level B)<sup>14, 18</sup>. Tests with 20% or more of manual and/or automatic exclusions of readings are probably due to inadequate technique concerning the device or inappropriate patient behavior. Under some circumstances, such as loss of readings in non-relevant time periods, a number of readings lower than that advocated may be acceptable at the physician's discretion (Degree of Recommendation IIb – Evidence Level D).

It is mandatory that ABPM report includes all of the items listed in table 13 (Degree of Recommendation IIa – Evidence Level D)<sup>77</sup>.

**Table 13 - Aspects that should necessarily be evaluated in an ABPM report<sup>76</sup>**

- |   |
|---|
| <ul style="list-style-type: none"> <li>• Quality of the examination</li> <li>• Mean blood pressures</li> <li>• Day-night differences in blood pressure</li> <li>• Correlations between pressures and activities, symptoms and medications</li> <li>• Peak tensions and hypotension episodes</li> <li>• Conclusions</li> </ul> |
|---|

In accordance with the information currently available, a hypertensive diagnosis using ABPM should not be made, since this is a clinical diagnosis (Degree of Recommendation Ia – Evidence Level A). Upon completion, the report should include normal or abnormal blood pressure behavior, and mention all drugs in use (anti-hypertensives or not) (Degree of Recommendation IIa – Evidence Level D).

## 12. The future of the method

The judicious use of ABPM based on scientifically acceptable conclusions, and its growing application, will lend the necessary support to a widespread use of the method, exploring its main advantages for the understanding of hypertension and care required for its treatment. The applications and possible uses of ABPM in the future include: a) adjustable cuffs; b) evaluation of other parameters, besides systolic and diastolic pressures, such as heart rate, pulse pressure, pulse velocity and waveform, morning surge in blood pressure; c) development of international unified protocols for validation of devices; d) reference values for 24-hour ABPM; e) prospective studies for prognostic evaluation of diagnoses of populations followed by ABPM; f) determination of the usefulness of ABPM in special populations, including pregnant women, children and diabetics; g) development of reliable, portable and low-cost monitors for non-invasive recording of beat-to-beat blood pressure<sup>78-79</sup>.

# II Guideline for Home Blood Pressure Monitoring

## 1. Definition

Home Blood Pressure Monitoring (HBPM) refers to an indirect method of recording blood pressure, in the morning and at night, over a five-day period, performed by the patient or other trained person, during daytime, at home or at the workplace. It should not be mistaken for self-blood pressure monitoring, which is the non-systematized recording of blood pressure conducted according to the orientation of the patient's physician.

## 2. Indications, advantages, and limitations

Foremost among the primary indications of HBPM (Table 14),<sup>80-92, 102</sup> are the assessment of anti-hypertensive therapy and follow-up of patients with white-coat hypertension. HBPM is a useful alternative to overcome the inconveniences associated to blood pressure measurement taken at the physician's office<sup>82, 92-104</sup> thanks to its numerous advantages (Table 15), the most important of which are the possibility of taking a greater number of readings outside the office setting and good acceptance of the method. The major limitation of HBPM is the difficulty to take the readings during sleep (Table 16)<sup>26, 105-106</sup>.

This is not an innovative approach, since in 1940 it was already demonstrated that home measurements yielded values from 30 to 40 mm Hg lower than office measurements<sup>107</sup>. Blood pressure values obtained by HBPM are lower than those obtained in the office (Degree of Recommendation I – Evidence Level B)<sup>108</sup>. The development of compact, digital devices that are reliable, validated and affordable allowed the procedure to be used in large scale both in daily clinical practice and research.

**Table 14 - Indications for HBPM**

- Identification and follow-up of white-coat hypertensive patients (Degree of Recommendation I – Evidence Level B)<sup>79,80,81,101</sup>
- Identification of white-coat effect (Degree of Recommendation I – Evidence Level B)<sup>81</sup>
- Identification of masked hypertension (Degree of Recommendation IIa – Evidence Level B)<sup>82,83</sup>
- Evaluation of anti-hypertensive therapy (Degree of Recommendation IIb – Evidence Level B)<sup>84-9,90</sup>

**Table 15 - Potential advantages of HBPM related to casual measurement (Degree of Recommendation I – Evidence Level B)**

- Larger number of measurements<sup>91</sup>
- Good acceptance, including by the old and very old<sup>92</sup>
- Enhanced compliance with treatment<sup>93,94</sup>
- Good reproducibility<sup>95</sup>
- Quantification of the white-coat effect<sup>81,96,97,98,99</sup>
- Evaluation of blood pressure without the influence of the presence of an observer and the office environment<sup>100</sup>
- Attenuation of mistakes and preferences of the observer<sup>101</sup>
- Better correlation with target organ damage<sup>100</sup>
- Possibility to store, print and transfer readings remotely<sup>93</sup>
- Fewer number of visits to the doctor<sup>102</sup>
- Low cost of monitors<sup>103</sup>

## 3. Equipment

Digital, compact, validated devices fitted with data-storing memory and/or built-in printer, or capable of transmitting data to a central unit are recommended. Most validated devices are designed for upper arm measurement (Degree of Recommendation I – Evidence Level D). Wrist measuring devices are of restricted use (Degree of Recommendation IIb – Evidence Level D), and finger measuring devices are contraindicated (Degree of Recommendation III – Evidence Level D)<sup>109-110</sup>.

Table 17 lists the factors that should be considered when acquiring a HBPM device.

## 4. Protocol for performing the examination and instructing the patient

The following protocol is recommended (Table 18) for HBPM examination (Degree of Recommendation IIa – Evidence Level D).

- performed during the five working days of the week (Degree of Recommendation IIa – Evidence Level D);
- the first day is dedicated to instructions, training, selection of the arm with the highest blood pressure values, where measurements will be taken (Degree of Recommendation IIa – Evidence Level D), and delivery of the device (Tables 19 and 20) (Degree of Recommendation IIa – Evidence Level D);<sup>26, 111-121</sup>
- during the next four days, blood pressure should be taken at least three times in the morning and three times at night, between 6:00 and 10:00 am and 6:00 and 10:00 pm (Degree of Recommendation IIa – Evidence Level A).<sup>26, 122-123</sup>

**Table 16 - Limitations of HBPM (Degree of Recommendation IIa – Evidence Level D)<sup>25,101,104-5</sup>**

- Difficulty to have measurements taken during sleep
- Time spent instructing patient and/or members of family
- Reduced number of normality studies and prognosis
- Arrhythmic and obese patients, as well as children
- Induced by the readings, patient may self-adjust medication

**Table 17 - Aspects to be considered when buying an HBPM device (Degree of Recommendation I – Evidence Level D)**

- Device validated by the *British Hypertension Society* and the *Association for the Advancement of Medical Instrumentation* or, at least, by one of these protocols, as long as it has not been reproved by the other
- Cost of the device and *software*
- Enough memory to allow protocol execution
- Printing of data
- Manual with appropriate instructions
- Cost of maintenance
- Cost of consumables (e. g: batteries)
- Cuffs of several sizes
- Technical support available
- Warranty period

## 5. Normality criteria

Based on the analysis of international studies and guidelines, it is recommended that mean blood pressure above 135/85 mm Hg (Degree of Recommendation I – Evidence Level B) be considered abnormal (Table 21).<sup>95, 102, 124-125</sup> Just as in blood pressure measurements taken in the office, lower HBPM values should be considered in high risk patients (diabetes mellitus, renal failure and heart failure). In children and pregnant women, normality criteria have not yet been established (Degree of Recommendation I – Evidence Level D).<sup>26, 126-128</sup>

Day of the week	Orientations	
<b>Monday</b>	Instructions and delivery of the device	The values obtained at the clinical setting are used to evaluate the alarm reaction
<b>Tuesday</b>	First day of measurements according to the protocol	Values excluded from the overall mean value
<b>Wednesday, Thursday and Friday</b>	Second, third and fourth day of measurements	The mean value for these days are calculated for ABPM analysis

Note: All blood pressure values should be included in the report

<ul style="list-style-type: none"> <li>Take the measurements in a quiet environment with a comfortable temperature, with an empty bladder, without having exercised in the previous 60 minutes, without having drunk alcohol or coffee nor having eaten or smoked in the previous 30 minutes. Remain silent during the procedure. (Degree of Recommendation I – Evidence Level B)<sup>110-117</sup></li> <li>Obtain the measurements before taking medications and before breakfast and dinner, or two hours after these meals. (Degree of Recommendation I – Evidence Level D)<sup>25, 118</sup></li> <li>Obtain the measurements in a sitting position after two minutes of rest, with the back supported and the legs uncrossed, observing a one-minute interval between measurements (Degree of Recommendation I – Evidence Level D)<sup>25</sup></li> <li>Use always the same arm defined on the instruction day, supported at heart level and with the palm of the hand facing up; remain still during the measurements (Degree of Recommendation I – Evidence Level B)<sup>111, 119, 120</sup></li> </ul>
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<ul style="list-style-type: none"> <li>Inform the patient about blood pressure variation: "Blood pressure varies at every heart beat"</li> <li>Emphasize that, in most people, out-of-the office blood pressure is lower</li> <li>Explain that slight differences in the readings (140/130 mmHg) are usually artifacts</li> <li>Instruct him/her to take the measurements during the recommended days and times, without changing daily routine</li> <li>Recommend him/her not to take blood pressure of other people using devices assigned only to one person</li> </ul>
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Abnormal Mean Blood Pressure (mm Hg)	
Systolic	Diastolic
>135	>85

## 6. Clinical value of HBPM

### 6.1. Diagnosis of white-coat hypertension

HBPM allows the diagnosis of white-coat effect and hypertension. Although HBPM is not as appropriate as ABPM in the diagnosis of white-coat hypertension, it is indicated in the follow-up of these patients because of its low cost and convenience (Degree of Recommendation I – Evidence Level B).<sup>80, 81, 82, 129</sup>

### 6.2. Evaluation of the efficacy of anti-hypertensive therapy

Because of its low cost,<sup>130</sup> good acceptance,<sup>131</sup> and ease of use, as well as the possibility to allow medium- and long-term evaluation and distance monitoring, HBPM is appropriate for evaluating the efficacy of anti-hypertensive therapies. Several studies have shown the usefulness of HBPM in the assessment of patients with refractory hypertension (Degree of Recommendation I – Evidence Level A).<sup>26, 82, 85, 87-91, 132</sup>

### 6.3. Prognosis of hypertensive patients

Prospective studies have showed an increasing role of HBPM in evaluation of prognosis related to office blood pressure measurement.<sup>83, 132, 133</sup> The Ohasama study, which analyzed a large number of individuals during a long time, demonstrated that HBPM is correlated with total cardiovascular mortality rate, morbidity from stroke and non-cardiovascular mortality.<sup>132</sup> The 10-year follow-up period showed that the rise of 10 mmHg in blood pressure obtained by HBPM increased stroke risk by 35%.

Several studies have shown that HBPM has a better correlation with the left ventricle mass index than office measurement (Degree of Recommendation I – Evidence Level C).<sup>108, 134</sup>

## 7. Interpretation of data obtained and production of reports (Degree of Recommendation I – Evidence Level D)

The HBPM report should include the following aspects:

- Description of the protocol followed
- Quality of the procedure

The record should be accepted for interpretation when it reaches at least 12 valid measures (Degree of Recommendation I – Evidence Level B), as long as there are valid measures each day during the test (Degree of Recommendation IIa – Evidence Level D)<sup>90, 133</sup>. Aberrant measurements should be excluded, such as diastolic pressure above 140 mmHg and below 40 mmHg, systolic pressure below 70 mmHg and above 250 mmHg and pulse pressure below 20 mmHg or above 100 mmHg, provided there is no clinical justification (Degree of Recommendation I – Evidence Level D).

- Mean blood pressures

The report should include both daily mean blood pressure and total blood pressure. It is interesting to analyze mean blood pressure

values obtained in the morning and at night, especially in patients under drug therapy. These mean values are obtained through effective records of at least four days, excluding values collected in the first day of monitoring. It should be emphasized that the values obtained during this day should be included in the record for evaluation of the alarm reaction. When mean blood pressures are above 135 and/or 85 mm Hg, it is recommended that the test be considered as abnormal (Degree of Recommendation I – Evidence Level A)<sup>95, 124-125</sup>.

## 8. Special situations

### 8.1. Elderly patients

Physical and cognitive limitations may restrict use of HBPM in geriatric patients, making the aid of another person necessary in order to ensure compliance with protocol. Special attention should be given to the increase of arterial stiffening, often seen in these patients, which may compromise the accuracy of data obtained through the use of oscillometric devices. Prior evaluation through Osler maneuver may be useful for identification of these cases. Studies have shown the benefit of HBPM in therapeutic control of elderly patients (Degree of Recommendation I – Evidence Level B).<sup>83, 90</sup>

### 8.2. Pregnant women

This method may be useful for evaluation of white-coat hypertension in pregnant women. The few studies available suggest the value of HBPM in the gestational period, because it allows better control of blood pressure and reduces the number of visits (Degree of Recommendation I – Evidence Level C).<sup>128, 135</sup>

### 8.3 Children and adolescents

There are few studies using HBPM in children and adolescents, and this restricts its clinical application. Despite being a complementary source of information, it should not be used for decision making in this population (Degree of Recommendation I – Evidence Level D)<sup>126</sup>.

## 9. Perspectives of HBPM

Some devices currently available can store records and transmit them via telephone or internet to a central computer, providing greater adherence and better control of blood pressure with fewer number of visits to the doctor's office (Degree of Recommendation I – Evidence Level B)<sup>127, 136-138</sup>.

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