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POSITION PAPER

# Standards for the Implementation, Analysis, Interpretation, and Reporting of 24-hour Ambulatory Blood Pressure Monitoring Recommendations of the Italian Society of Hypertension

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## Abstract

Twenty-four-hour ambulatory blood pressure monitoring (ABPM) is recognized as a reference tool for accurately diagnosing hypertension. Until a few years ago, this technique was restricted to use by specialists. Recently, however, due to the need for wider availability and thanks to technological innovation, simplification of analysis processes, and increasing recognition of the importance of this tool for the diagnosis of hypertension, ABPM is now also being used in non-specialist settings. In such settings, ABPM is used with a two-pronged approach: (i) independently by a general practitioner with the possibility of specialist supervision for particular and complex cases; (ii) in the non-medical setting (community pharmacies, home care services, etc.) where the healthcare provider is trained in the proper use of the technique, with the understanding a physician must be responsible for the final clinical reporting. Unfortunately, due to the increasingly wide diffusion of ABPM, there has been considerable confusion about management roles and responsibilities in recent years. To clarify competencies and roles and standardize the processes related to the technique's implementation and proper management, experts of the Blood Pressure Monitoring Working Group of the Italian Society of Hypertension have drafted this document with the aim of providing a quick and easy reference guide for training healthcare professionals in the field.

**Keywords** Ambulatory blood pressure monitoring · Hypertension · White-coat hypertension · Masked hypertension · Dipping status · Blood pressure variability

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## 1 Introduction

Ambulatory blood pressure monitoring (ABPM) is now widely recognized as the tool of choice for accurately diagnosing hypertension. Until a few years ago, the use of this method was limited to the specialist field. Thanks to technological innovation, the simplification of testing processes, and the need to facilitate an early and effective diagnosis of hypertension, in recent times, this technique has also been progressively introduced in non-specialist settings (e.g., general practitioner clinics, community pharmacies, home care services, etc.). In non-specialist settings, ABPM is used with a two-pronged approach: (i) use by non-specialized physicians, e.g., general practitioners, who are in such a case trained in the independent use of the technique, including reporting, with the possibility of specialist supervision for particular and complex cases; (ii) use in non-medical settings (e.g., community pharmacy, nursing home care service, etc.) where the healthcare provider is trained in the proper use of this technique, with the understanding that a physician must be responsible for the final clinical report.

Unfortunately, due to the enormous diffusion of this method of BP measurement in the healthcare setting, there has been considerable confusion in recent years about roles and competencies in the management of the diagnostic technique. To clarify these aspects and standardize the processes related to the implementation and clinical interpretation of this technique, the Italian Society of Hypertension has written this document aimed at providing a reference guide for training healthcare professionals in the field. The document is, therefore, deliberately schematic and simple to ensure easily accessible and clear guidance for implementation and correct use of the ABPM methodology in daily clinical practice.

## 2 Italian Guidelines on Blood Pressure Monitoring: A Bit of History

The Italian Society of Hypertension was among the first medical-scientific societies to publish specific recommendations on BP measurement techniques.

- 1995: publication of the first guidelines on ABPM [1].
- 2008: publication of the first guidelines on conventional and automated BP measurement in the doctor's office, at home, and over 24 h [2].
- 2015: publication of the standards for ABPM reporting [3].

In the current document, the previous guidelines of the Italian Society of Hypertension are updated in light of the latest scientific evidence, recent technological developments, and the accumulated clinical experience in this field. They are integrated with the indications of the most recent guidelines of the European Society of Hypertension and other medical-scientific societies [4–8].

## 3 Advantages and Limitations of Ambulatory Blood Pressure Monitoring

### 3.1 Advantages

- Several BP measurements can be obtained outside the doctor's office in the usual environment of the subject under evaluation.
- Provides BP values during daily activities and notably during night sleep.
- Provides an objective assessment of BP as it is free from operator-related errors (e.g., *"digit preference"*, *"observer bias"*).
- Automatic BP measurement is devoid or almost devoid of the white-coat effect.
- It is unaffected by the placebo effect and retains good reproducibility over time when the 24-hour average value is considered.
- Allows identification of two important hypertension phenotypes: white-coat hypertension and masked hypertension.
- Allows identification of other potentially useful parameters, including BP variability.
- Provides an accurate picture of the degree of 24-hour BP control with drug treatment, which is very useful for confirming uncontrolled hypertension and mandatory for resistant hypertension diagnosis.
- Essential for assessing nocturnal BP, the presence or absence of the physiological nocturnal BP fall (*"dipper status"*), and the occurrence of isolated nocturnal hypertension, a particular type of masked hypertension.
- Useful to identify an excessive hypotensive effect of antihypertensive drug treatment.
- Prognostic value is higher than that of office BP.

### 3.2 Limitations

- Not widely available in a non-specialist setting.
- Relatively expensive and potentially time-consuming for the healthcare professional.

- May cause discomfort to the patient, particularly during sleep, reducing patient cooperation and interfering with sleep quality and duration.
- Reluctance of some patients to perform the test, especially when repeated.
- Possible inaccuracy of measurements and risk of motion artifacts during daily activities.
- Imperfect reproducibility of BP values within 24-hours (e.g., single values or hourly averages), also due to difficulty in standardizing individual behaviors during 24-hours.

# 4 Technological Requirements

## 4.1 Device Requirements

Technical requirements for ABP monitors have been recently detailed in a position paper of the European Society of Hypertension [7].

### 4.1.1 Essentials

- Automated electronic upper arm cuff devices.
- Validation of the device and cuffs in a general population according to the AAMI/ESH/ISO Universal Standard—ISO 81,060–2:2018 and its amendments [9]. Validation with previous international protocols is still acceptable for devices already on the market. A list of clinically validated devices is available on the STRIDE BP website (https://stridebp.org/), developed by the experts of the European and International Society of Hypertension and World Hypertension League.
- Additional validation in special populations (e.g., children, pregnant women, arm circumference > 42 cm, atrial fibrillation).
- Allow to set BP measurements every 15, 20, 30, or 60 min for 24-hours.
- Impending measurement alert for the user shortly before each measurement (limited to the waking hours).
- Calculation of specific parameters and presentation of results through a *"standardized single-page report"* (see Sect. 7).

**Table 1** Arm cuff size

| Type of arm cuff | Arm circumference (cm) |
|---|---|
| Small or S (pediatric) | Between 14 and 22–26 |
| Medium or M (regular adult) | Between 22–26 and 32–34 |
| Large or L (obese adult) | Between 32–34 and 38–44 |
| Extra large or XL (large obese adult) | Between 38–44 and 48–52 |

### 4.1.2 Optional

- Calculation of additional parameters (see Sect. 7).
- Possibility of atrial fibrillation screening with specific validated algorithms (for selected populations, e.g., age ≥ 65 years).

### 4.1.3 Other Aspects

- Smaller, lighter, and less noisy devices to maximize user tolerability.
- Lower cost of devices and cuffs.
- Washable or disposable cuffs with soft materials.
- Integration with actigraphy or position sensor to precisely pinpoint waking and sleeping periods as well as performance of physical activity.
- Ability to check the original oscillogram for each measurement and thus verify the actual quality of the calculated BP values.

## 4.2 The Arm Cuff

The size of the inflatable rubber bladder contained in the inelastic cloth forming the cuff is particularly important since it must match the arm circumference of the patient. The use of too-narrow bladders leads to an overestimation of BP (undercuffing). In contrast, the use of too-wide bladders can lead to an underestimation of BP (overcuffing). Cuff sizes can vary from manufacturer to manufacturer; a list of the most common cuff sizes is shown in the Table 1. The cuff shape also has its importance, especially in overweight and obese individuals who have a tronco-conical arm shape [10]. When managing these individuals, it would be advisable, if possible, to choose a tronco-conical cuff of appropriate size for better matching the cuff to the patient's arm, compared with using a cylindrical cuff [11, 12]. Currently, only a few device models are equipped with tronco-conical cuffs (an updated list can be found on the STRIDE BP website at https://stridebp.org/).

## 4.3 Maintenance

The 24-hour BP monitor (and its cuffs) should be regularly maintained according to the following indications:

- For hygienic purposes and to ensure the long life of the arm cuff, it must be cleaned after each use using a soft cloth soaked in non-alcoholic detergent.

- At the end of each recording, the good condition of the BP monitor and cuffs must be checked; in particular, the cuff and tubing integrity must be verified.
- The device must be calibrated biannually at an authorized center and re-calibrated if it is found inaccurate.

## 5 Potential Technical Problems

### 5.1 Major Problems

These are problems that make recording potentially inaccurate and are difficult to overcome:

- Possibility of inaccurate measurements in the presence of arrhythmia, especially in the case of atrial fibrillation (unless the BP monitor has a validated algorithm for measurement in the presence of arrhythmia).
- Frequent use of the arm wearing the cuff during the measurement (e.g., drivers, manual workers, athletes, etc.) can increase the frequency of artifacts and inaccurate values and thus make the measurement unreliable.
- Poor patient cooperation can cause a large number of artifacts which may prevent an accurate assessment of the 24-hour BP profile.

### 5.2 Minor Problems

These are problems that are easily solved with proper precautions:

- Use of an inappropriately sized cuff can make the measurement inaccurate: a cuff of appropriate size should be used.
- Presence of significant BP difference between the two arms (systolic $\geq$ 20 mmHg and diastolic $\geq$ 10 mmHg): can be solved by applying the cuff to the arm with the higher BP.
- Presence of severe impairment of arm function (e.g., hemiplegia or paraplegia, hemodialysis fistula): where possible, do not use the affected arm or otherwise verify that BP can actually be measured accurately in the *"healthy"* arm.

### 5.3 Other Possible Sources of Artifactual or Inaccurate Measurements

- Incorrect positioning of the cuff.
- Dislocation of the cuff during monitoring.
- Use of an inappropriately sized cuff (cuff too small or too large).
- Arm position above or below heart level during measurement (e.g., during sleep when subjects lie in lateral decubitus).
- Arm movements during measurements (including vibrations while driving motorized vehicles or using machinery for work purposes).

## 6 ABPM Implementation

### 6.1 General Considerations and Recommendations

- 10–15 min are needed to fit the device.
- When fitting the device, it is necessary that the optimal conditions of the environment, the operator, and the patient required for a traditional office measurement are respected.
- It is necessary that the healthcare personnel dedicated to managing the test (usually a nurse or pharmacist) has been adequately trained to the correct procedure.
- It is recommended, unless otherwise indicated, to perform the recording on a routine working day.

### 6.2 Fitting the Monitor

The following is the sequence to be followed for proper application of the device:

- Initialize the BP monitor with the device software, carefully entering patient data (e.g., patient code) to avoid mistakes in patient identification when downloading the exam.
- Set the BP monitor to measure with a suitable frequency: preferably 20 min during the day and night (a high measurement frequency ensures more values and a more accurate diagnosis and allows more accurate assessment of BP variability - measurements every 15 min would be advisable for studies on BP variability).
- Program the monitor to hide BP values on the display during monitoring so as not to create anxiety or anticipation in the patient (the patient must be warned that BP values will not be shown on the display).
- The monitor can be programmed to warn through a beep of the impending measurement only during day-time hours, avoiding this warning during night-time sleep hours.

- Before starting the recording, check that there is no significant difference in BP levels between the two arms and use the nondominant arm whenever possible (see Sect. 5.2).
- Choose the appropriate cuff for the individual's arm circumference (see Sect. 4.2).
- Center the cuff over the brachial artery with the tubing facing up (thin disposable nonwoven cuff barrier sleeves can be used to preserve the cuff and avoid patient discomfort in warmer months due to sweating).
- Attach the BP monitor pouch to the waist with the appropriate belt or at the shoulder with the strap.
- Pass the cuff tubing behind the patient's neck and insert the connector into the monitor.
- Turn on the BP monitor and take a test measurement to verify proper operation of the device and to help familiarize the patient with the technique.
- Provide clear instructions to the patient and hand over an activity diary (see Sect. 6.2.1).

#### 6.2.1 Instructions to the Patient

First, it is necessary to explain to the patient:

- The characteristics of the test.
- The frequency of measurement.
- How to possibly stop a measurement.
- That the device repeats the measurement once in case of an error.

Therefore, it is necessary to recommend to the patient:

- To keep the arm still and at heart level during the measurement.
- Not to restrict, as much as possible, daily activities during the recording, but to stop them at the time of each cuff inflation.
- Not to drive or otherwise stop the vehicle when the measurement is taken or ignore the measurement.
- Not to disconnect the device during the night.
- To place the device on the bed or under the pillow at night.
- Not to mistreat the device or get it wet (e.g., by taking a shower or bath).
- To never remove the device.
- To periodically check that the cuff has not become dislodged or loose and, if so, to reposition it correctly (the patient should be instructed to check that the marker printed on the cuff is centered on the volar surface of the upper arm, 1–2 cm above the elbow crease, corresponding to the location of the brachial artery).

Finally, it is necessary to provide the patient:

- A reference phone number in case of problems or requests.
- Directions on how to turn off the device in case of malfunction.
- The diary on which to record the main activities of the day (an example of a diary is given in **Supplementary Information**) and in particular:
  - Diagnostic question (the reason why the patient is submitted to the procedure).
  - Type of medication being taken and time of dosing.
  - Time of falling asleep and waking up.
  - Quality of sleep.
  - Nap (siesta), if any, with time of start and end.
  - Time of main meals (indicating, if possible, whether the meal was light or heavy).
  - Main behavioral or work activities with time and characteristics.
  - Occurrence and time of any unusual or unplanned major event occurring during the recording (e.g., stressful situations, pain, unscheduled physical activity, etc.)
  - Time of onset of symptoms and their characteristics.

### 6.3 Removing the Monitor

- The device should be removed no sooner than 24 h after its application (best to wait 25 h to ensure completeness of recording).
- Verify that the diary has been completed, reporting normal activities and waking and sleeping periods.
- Immediately check the quality (see Sect. 7) and, if necessary, immediately repeat the recording or reschedule it.
- Remember to discard used batteries (if not rechargeable) to prevent them from being reused in a later recording or recharge the batteries if rechargeable.

## 7 Analysis of the Recording

The following sections outline how to analyze the recording for clinical purposes using software certified as a medical device capable of calculating essential parameters.

## 7.1 Quality Evaluation

### 7.1.1 Check and Removal of any Measurement Artifacts

Once the recording has been downloaded, it is necessary to proceed to check the occurrence of any artifacts, considering that the device automatically identifies and removes measurement errors of technical nature. It should be noted that the current trend is not to exclude any values from the recording since artifacts do not generally alter the calculation of the mean value on which the diagnostic evaluation is based [4].

Artifacts checking can be:

- Manual: preferred, based on visual inspection of the measurement list.
- Automatic: based on thresholds as detailed in Table 2 and 3. In general, it is recommended not to apply automatic artifact identification thresholds but rather to evaluate any potential artifacts in light of any activity or disturbances. Since, in some cases, artifactual measurements may be within the usual range of patient values, devices that provide oscillometric tracings that allow objective assessment of data quality should be preferred.

### 7.1.2 Quality Criteria

Quality criteria may vary depending on the purpose of the recording [2, 4, 6].

- For research purposes, more stringent criteria may apply:
  - At least 24 h of valid BP recording.
  - At least 70% of the readings expected based on preset frequency of measurement (provided that the monitor has been set to take a measurement at least every 20 min throughout the 24 h).
- For clinical purposes, less stringent criteria may apply:
  - At least 20 valid measurements during the day.
  - At least 7 valid measurements during the night.

In any case, the reporting physician may recommend repeating a test if the quality is deemed to be inadequate (e.g., in case of early termination of the recording overnight or absence of valid measurements during diagnostically relevant periods, or in conjunction with symptoms of hypotension).

**Table 2** Thresholds for automatic editing of ABPM [2]. The table reports the range of valid data for the analysis. BP: blood pressure

| Parameter | Minimum acceptable value | Maximum acceptable value |
|---|---|---|
| Systolic BP | 50 | 300 |
| Diastolic BP | 40 | 150 |
| Pulse pressure | 10 | 150 |
| Heart rate | 40 | 150 |

**Table 3** ABPM thresholds for hypertension [4, 6, 8]. ABPM: ambulatory blood pressure monitoring; BP: blood pressure

| | | |
|---|---|---|
| 24-hour average BP | ≥ 130/80 mmHg | Primary criterion |
| Day-time (awake) average BP | ≥ 135/85 mmHg | Day-time hypertension[1] |
| Night-time (asleep) average BP | ≥ 120/70 mmHg | Night-time hypertension[1] |

[1] Wake and sleep periods must be calculated based on the current sleep period reported in the diary by the patient

## 7.2 Recording Information from the Patient Diary

If the device is not equipped with an actigraph or a sensor that indicates body position, the healthcare provider carrying out the data download should record on the software the actual times of the patient's night-time sleep (from falling asleep to awakening and, if possible, also of any afternoon nap), as reported in the diary, for the correct calculation of awake and asleep parameters.

## 7.3 Minimal Requirements for Analysis

These following parameters must be mandatorily reported in the *"standardized single-page report"*:

- Summary on the quality of the recording: overall number of readings, number of valid readings, and percentage of valid readings based on the preset frequency of measurements.
- Average 24-hour, day-time (awake), and night-time (asleep) values for systolic and diastolic BP and heart rate (in the case of the night-time period, the average should be based on the actual hours of sleep reported by the subject in the diary or recorded with the actigraph or position sensor).
- Standard deviation (a measure of variability provided automatically by the software) of systolic and diastolic BP and heart rate for 24-hours, day-time (awake), and night-time (asleep); the latter based on actual hours of sleep reported by the subject in the diary or recorded with the actigraph or position sensor. It should be pointed out that although BP variability is an important prognostic marker, unlike average BP values there are

currently no universally accepted reference normal values for this measure [13].

- Difference between day-time (awake) and night-time (asleep) average for systolic and diastolic BP expressed as a percentage (BP dipping).
- List of individual measurements with time and minutes of detection (with an indication of the type of error, if any).
- Time trend of individual BP and heart rate measurements (graphical display with bands indicating normal limits for day-time and night-time BPs).

### 7.4 Optional parameters

- Minimum and maximum number of measurements per hour.
- Number of valid hours.
- Minimum and maximum value for systolic and diastolic BP, and heart rate for 24-hours, day-time (awake), and night-time (asleep).
- BP load: percentage of 24-hour BP values ≥ 130/80 mmHg, day-time (awake) BP values ≥ 135/85 mmHg, and night-time (asleep) BP values ≥ 120/70 mmHg.
- Other measures of variability: 24-hour "*weighed*" standard deviation and coefficient of variation (standard deviation normalized for the mean value and expressed as a percentage), Average Real Variability (ARV).
- Day-night (awake-asleep) difference in heart rate (expressed as a percentage).
- Time trend of hourly averages (graph).
- Average systolic and diastolic BP and heart rate for the first hour of the recording (*"white-coat effect window"*).

## 8 Interpretation of Results

### 8.1 ABP-based Reference Values for the Diagnosis of Hypertension

The reference values for the diagnosis of hypertension are based on the 24-hour, day-time (awake), and night-time (asleep) average. The 24-hour average BP is calculated using all measurements in the recording. In contrast, day and night-time BP averages must be calculated using the sleep period derived from the diary. No universally accepted reference values for BP variability are currently available. However, some evidence suggests that a day-time SBP variability of 15 mmHg and a night-time SBP variability of 12 mmHg might be a reasonable reference value [13].

**Table 4** ABP values corresponding to specific office BP values [17]. ABP: ambulatory blood pressure; BP: blood pressure

| Office BP | 24-hour average BP | Day-time (awake) average BP | Night-time (asleep) average BP |
|---|---|---|---|
| 120/80 mmHg (normal) | 115/75 mmHg | 120/80 mmHg | 100/65 mmHg |
| 130/80 mmHg (high-normal) | 125/75 mmHg | 130/80 mmHg | 110/65 mmHg |
| 140/90 mmHg (grade 1 hypertension) | 130/80 mmHg | 135/85 mmHg | 120/70 mmHg |
| 160/100 mmHg (grade 2 hypertension) | 145/90 mmHg | 150/95 mmHg | 130/80 mmHg |

**Table 5** Reference values for night-time BP fall [4, 6]. BP: blood pressure

| | |
|---|---|
| Asleep systolic and diastolic BP fall ≥ 10% | Dipper[1] |
| Asleep systolic or diastolic BP fall < 10% | Non-dipper[1] |

[1] Wake and sleep periods must be calculated based on the current sleep period reported in the diary by the patient

Recently, the HOPE Asia Network and the AHA/ACC guidelines based on prognostic studies and major hypertension guidelines [5, 8, 14–17] have proposed reference values for ambulatory BP at which cardiovascular risk corresponds to that observed for different levels of office BP (Table 4) [17]. It should be emphasized that these values have only a statistical significance, and the differences between office and ambulatory BP can be very different in individual patients.

### 8.2 Reference values for night-time (asleep) BP reduction

Assessing the dipping status is particularly important in certain conditions, such as pharmacologically treated patients, the elderly, and patients with kidney disease, diabetes, or dysautonomia, who may display a non-dipper status. Reference values for the dipping status are shown in Table 5. The dipping status is evaluated independently for systolic and diastolic BP.

A more detailed classification of the dipping status considers, among non-dippers, *"risers"*, i.e., those individuals who show an increase rather than a reduction in BP values during the night sleep, and, among dippers, *"extreme dippers"*, i.e., those individuals who have a night-time BP reduction > 20%. It must be emphasized that non-dipping, particularly rising, is associated with an increased risk of cardiovascular events; the same holds for extreme dipping in the elderly but not in the young [13].

### 8.3 Clinical Reporting

The clinical report should be prepared with a logical structure that considers the following sections:

- Judgement on the overall quality of the recording based on the quality criteria defined in Sect. 7.1.2. In case the quality is inadequate to make a judgment, the reporting physician should recommend repeating the test.
- Indication whether 24-hour, day-time (awake), and night-time (asleep) average systolic and diastolic BP values are within or above the normal limits. The reporting physician may also provide interpretation of any noteworthy BP variations occurring at certain times of the recording (e.g., episodes of hypotension or presence of white-coat effect in the early or terminal phases of the recording); however, the mean values are the reference for diagnosis (see Sect. 8.1).
- Description of circadian pattern of BP (and possibly heart rate, if noteworthy) with the indication of the dipper, non-dipper, or riser status and extreme dipping in the elderly.
- Indications of any increase in BP variability; however, since there are currently no recognized normal reference values for BP variability, this evaluation should be mainly qualitative, based on inspection of the graph of individual BP values, with reporting of any periods characterized by particularly high or low values, especially in subjects on antihypertensive treatment.
- Conclusion about a normotensive or hypertensive condition and the degree of BP control in treated patients (e.g., adequate or inadequate, with possible reference to day-time and night-time periods, and systolic or diastolic BP, as appropriate).

Some analysis software includes the functionality to automatically generate the report's text. This functionality may be acceptable, provided that the final text contains all the standard report elements indicated above and that the reporting physician verifies and validates its accuracy and completeness. However, the entry of an excessive number of parameters with no clinical application should be avoided.

## 9 Clinical Indications to ABPM

ABPM is considered by many guidelines to be the best approach to an accurate diagnosis of hypertension. Therefore, it should be performed whenever possible in all patients with findings of elevated BP values in the clinical setting to confirm a diagnosis of hypertension. The main specific indications for performing ABPM are:

- Conditions in which white-coat hypertension is more common (e.g., grade 1 hypertension based on office measurement, marked increase in office BP in the absence of organ damage).
- Conditions in which masked hypertension is more common (e.g., high-normal office BP, normal office BP in individuals with organ damage or high cardiovascular risk, excessive BP reaction to exercise stress testing).
- Treated subjects:
  - To confirm the presence of true resistant hypertension.
  - Assessment of 24-hour BP control (especially in high-risk patients).
  - Assessment of BP changes in conjunction with symptoms suggestive of arterial hypotension (especially in older people).
- Suspected postural or postprandial hypotension in treated subjects.
- Exaggerated BP response to exercise.
- Exaggerated BP response on the transition from supine to standing posture.
- Considerable variability between office BP measurements.
- Difference between office and home self-BP measurement.
- Assessment of nocturnal BP and dipping status (e.g., obstructive sleep apnea syndrome, renal failure, diabetes, endocrine hypertension, or dysautonomia).
- Patients unable or unwilling to perform reliable home BP monitoring or anxious about self-measurement.
- Pregnancy.

### 9.1 Repeating the Recording

ABPM can be repeated periodically to ensure adequate BP control, particularly in patients at increased cardiovascular risk. The frequency depends on availability, risk level, and individual preference. The following indications generally apply [6]:

- Hypertension not controlled by therapy: could be performed every 2–3 months until normalization of 24-hour BP profile.
- Controlled hypertension: could be performed annually.
- To confirm the diagnosis of white-coat or masked hypertension.

**Table 6** Ambulatory systolic and diastolic BP values corresponding to 95th percentile in males and females, according to age [5]. BP: blood pressure

| Age (years) | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | 24-hour | Day-time (awake) | Night-time (asleep) | 24-hour | Day-time (awake) | Night-time (asleep) |
| 5 | 113 / 72 | 123 / 81 | 106 / 65 | 115 / 74 | 121 / 82 | 108 / 69 |
| 6 | 115 / 73 | 124 / 81 | 108 / 66 | 116 / 74 | 122 / 82 | 110 / 68 |
| 7 | 116 / 73 | 125 / 82 | 110 / 67 | 118 / 74 | 123 / 82 | 111 / 67 |
| 8 | 117 / 73 | 125 / 82 | 111 / 67 | 119 / 74 | 124 / 82 | 112 / 67 |
| 9 | 118 / 73 | 126 / 82 | 112 / 67 | 120 / 74 | 125 / 82 | 112 / 67 |
| 10 | 119 / 73 | 127 / 82 | 113 / 67 | 121 / 75 | 126 / 81 | 113 / 67 |
| 11 | 121 / 74 | 129 / 82 | 115 / 67 | 122 / 75 | 127 / 81 | 114 / 66 |
| 12 | 124 / 74 | 132 / 82 | 116 / 67 | 123 / 76 | 128 / 82 | 114 / 66 |
| 13 | 126 / 74 | 135 / 82 | 119 / 67 | 124 / 76 | 129 / 82 | 114 / 66 |
| 14 | 129 / 75 | 138 / 82 | 121 / 67 | 125 / 76 | 130 / 82 | 114 / 65 |
| 15 | 132 / 75 | 141 /83 | 123 / 66 | 125 / 77 | 130 / 82 | 114 / 65 |
| 16 | 135 / 76 | 144 / 84 | 126 / 66 | 126 / 77 | 131 / 82 | 114 / 65 |

**Table 7** Ambulatory systolic and diastolic BP values corresponding to 95th percentile in males and females, according to height [5]. BP: blood pressure

| Height (cm) | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | 24-hour | Day-time (awake) | Night-time (asleep) | 24-hour | Day-time (awake) | Night-time (asleep) |
| 120 | 117 / 77 | 125 / 82 | 106 / 63 | 114 / 72 | 120 / 82 | 106 / 65 |
| 125 | 118 / 77 | 125 / 82 | 108 / 63 | 116 / 73 | 121 / 82 | 107 / 66 |
| 130 | 119 / 77 | 126 / 82 | 110 / 64 | 117 / 73 | 122 / 82 | 108 / 66 |
| 135 | 120 / 77 | 126 / 82 | 111 / 65 | 118 / 74 | 123 / 82 | 109 / 66 |
| 140 | 121 / 77 | 126 / 82 | 113 / 65 | 119 / 75 | 124 / 82 | 110 / 66 |
| 145 | 123 / 77 | 127 / 81 | 114 / 66 | 120 / 75 | 125 / 82 | 112 / 66 |
| 150 | 124 / 77 | 128 / 81 | 116 / 66 | 121 / 76 | 127 / 82 | 113 / 66 |
| 155 | 126 / 77 | 130 / 81 | 117 / 66 | 123 / 76 | 128 / 82 | 114 / 66 |
| 160 | 127 / 77 | 133 / 81 | 118 / 66 | 123 / 76 | 129 / 82 | 114 / 66 |
| 165 | 129 / 78 | 135 / 82 | 119 / 66 | 124 / 76 | 130 / 82 | 114 / 66 |
| 170 | 131 / 78 | 138 / 82 | 121 / 66 | 125 / 76 | 131 / 82 | 115 / 71 |
| 175 | 133 / 78 | 140 / 83 | 122 / 66 | 126 / 76 | 131 / 82 | 115 / 66 |
| 180 | 134 / 78 | 142 / 83 | 124 / 66 | - | - | - |
| 185 | 136 / 78 | 144 / 84 | 125 / 66 | - | - | - |

## 10 ABPM in Special Populations and Conditions

### 10.1 Children and Adolescents

Difficulties in ABP measurement may be encountered in children and adolescents for several reasons:

- Lack of specific validation of oscillometric devices.
- Uncertain reference values.
- Few devices validated.
- Uncertain diagnostic role.
- Arterial compliance and cuff-size-related issues.

According to current recommendations, the reference values to be used in children and adolescents, if age is used as the reference, are as follows [5]:

- Age < 16 years: the reference value is the 95th percentile shown in Table 6.
- Age ≥ 16 years: adult cut-offs apply.

In case height is used as a reference, the recommended reference value (95th percentile) is reported in Table 7.

### 10.2 Elderly People

In older people, ABPM is particularly useful for assessing:

- Masked hypertension (particularly frequent in individuals on antihypertensive treatment).
- White-coat hypertension (less frequent than masked hypertension).
- The elevated BP variability and extreme dipping typical of the elderly.

- Possible hypotensive phenomena, more frequent in subjects on antihypertensive treatment.

## 10.3 Pregnancy

Difficulties in ABP measurement may be encountered in pregnant women for several reasons:

- Lack of validation studies of oscillometric devices for this population.
- Uncertainty about reference BP values for diagnosis and target BP values for treatment.
- Few validated devices.
- Uncertain diagnostic role in the pathway of care.
- Underestimation of BP in pre-eclampsia.

Pregnancy is a high-risk condition for developing hypertension. Since pregnancy is often characterized by white-coat hypertension and nocturnal hypertension, ABPM plays an important role as long as the specific reference values for pregnant women based on gestational age are used for diagnosis; these values are lower than those measured in non-pregnant women, except for the last gestational weeks. A proposal of reference values (corresponding to the mean + 2 standard deviations) is given in Table 8: these values were obtained in a single study and need confirmation in further studies [4, 18].

## 10.4 Arterial Hypotension

The indications for ABPM also include arterial hypotension. This is particularly relevant in the following conditions:

- Elderly, particularly if on antihypertensive treatment.
- Patients with conditions that may be associated with a risk of hypotension (e.g., dysautonomia and diabetes mellitus).
- Patients under antihypertensive drug treatment that may exhibit an excessive hypotensive effect.

It should be remembered that there is currently no ABP reference for diagnosing arterial hypotension. Therefore, the diagnosis must be based on common sense and verifying BP changes within the monitoring period.

However, the so-called *"hypotensive phenotype"* has recently been described. In patients subject to syncope, systolic BP values below 90 or 100 mmHg during day-time hours correlate with a higher syncope frequency [19].

**Table 8** Reference values for ABP in pregnancy according to gestational age. Data are shown as average + 2 standard deviations for the 24-hours and the night-time (asleep) [18]. BP: blood pressure

| Gestational age (weeks) | 24-hours | Night-time (asleep) |
|---|---|---|
| 9–17 | 121 / 73 | 110 / 64 |
| 18–22 | 126 / 76 | 114 / 66 |
| 26–30 | 128 / 78 | 117 / 68 |
| 31–40 | 131 / 82 | 123 / 72 |

## 10.5 ABPM in Special Settings

One of the main purposes of this document is to provide clear guidance to healthcare professionals working in primary care for the correct implementation of ABPM and standardization of the interpretation of results. The gradual dissemination and proper use of ABPM outside of specialist settings and under the supervision of the specialist can promote access to the diagnostic technique for both the first diagnosis and follow-up of a hypertensive patient.

## 10.6 General Practice

In recent years, ABPM has become increasingly popular among general practitioners who can independently perform the recordings and provide a medical report of the test. In this case, the specialist acts as a support in those situations where interpretation may be doubtful or difficult. Nursing staff often support the general practitioner in managing single patients undergoing ABPM. Essential requirements that the general practitioner must possess to offer ABPM to patients are:

- To be equipped with a clinically validated BP monitor with cuffs of different sizes (minimum requirement: one standard and one large cuff) and analysis software. In case the physician does not want to take care of ABPM medical reporting, she/he may refer to a certified telemedicine platform where a specialist can take over this task or remotely support the general practitioner in the reporting process.
- To undergo suitable training and re-training courses run by specialists and to follow the recommendations of the guidelines.
- To guarantee regular maintenance of the BP monitor being used, according to the recommendations of the guidelines and the manufacturer.

## 10.7 Community Pharmacy

With the enactment of the Law Decree of 12/16/2010 (*"Pharmacy of services"*, in Italian *"Farmacia dei servizi"*), Italian pharmacies are now able to provide ABPM to patients upon medical prescription.

Essential requirements that pharmacists must possess to offer ABPM to their patients are:

- To be equipped with a clinically validated BP monitor with cuffs of different sizes (minimum requirement: one standard and one large cuff) in connection with a certified telemedicine platform and provider (namely a remote facility ensuring that performance and reporting of ABPM are both carried out following current guidelines and by trained and experienced doctors).
- To undergo appropriate training by the telemedicine service provider by obtaining an initial certification for the use of the technique and then periodic re-certification following a re-training course.
- To guarantee regular maintenance of the BP monitor being used according to the recommendations of the guidelines and the manufacturer.

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