Consensus Document

# European Society of Hypertension practice guidelines for ambulatory blood pressure monitoring

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Given the increasing use of ambulatory blood pressure monitoring (ABPM) in both clinical practice and hypertension research, a group of scientists, participating in the European Society of Hypertension Working Group on blood pressure monitoring and cardiovascular variability, in year 2013 published a comprehensive position paper dealing with all aspects of the technique, based on the available scientific evidence for ABPM. The present work represents an updated schematic summary of the most important aspects related to the use of ABPM in daily practice, and is aimed at providing recommendations for proper use of this technique in a clinical setting by both specialists and practicing physicians. The present article details the requirements and the methodological issues to be addressed for using ABPM in clinical practice, The clinical indications for ABPM suggested by the available studies, among which white-coat phenomena, masked hypertension, and nocturnal hypertension, are outlined in detail, and the place of home measurement of blood pressure in relation to ABPM is discussed. The role of ABPM in pharmacological, epidemiological, and clinical research is also briefly mentioned. Finally, the implementation of ABPM in practice is considered in relation to the situation of different countries with regard to the reimbursement and the availability of ABPM in primary care practices, hospital clinics, and pharmacies.

**Keywords:** ambulatory blood pressure monitoring, arterial hypertension, clinic blood pressure measurement, clinical indications, guidelines, home blood pressure measurement, practice recommendations

**Abbreviations:** AASI, ambulatory arterial stiffness index; ABP, ambulatory blood pressure; ABPM, ambulatory blood pressure monitoring; BP, blood pressure; BPM, blood pressure monitoring; ESC, European Society of Cardiology; ESH, European Society of Hypertension; HBPM, home blood pressure monitoring; NICE, National Institute for Health and Clinical Excellence; OBPM, office blood pressure measurement

Ambulatory blood pressure monitoring (ABPM) has become a subject of considerable scientific interest with over 10 000 articles listed on *PubMed* by 2012. In 2001, the Center for Medicare and Medicaid Services in the United States approved ABPM for reimbursement for the identification of individuals with white-coat hypertension, and in 2011 the National Institute for Health and Clinical Excellence in the United Kingdom recommended that ABPM should be offered as a cost-effective technique to all people suspected of having hypertension. In recognition of the importance of ABPM in clinical practice and research on hypertension, the Working Group on Blood Pressure Monitoring and Cardiovascular Variability of the European Society of Hypertension (ESH) held a consensus conference on ABPM in Milan in 2011. Arising from this meeting, a position paper was published in 2013 incorporating the opinions of 34 international experts in hypertension and blood pressure (BP) measurement [1]. This position paper, running to 38 pages, is a comprehensive state-of-the-art review on ABPM and draws on the evidence from over 600 papers on the subject published until 2013.

The ESH 2013 ABPM position paper will serve as a reference source for ABPM, but it was recognized that a shorter guideline is needed for clinical practice, and in this concise guidelines paper the main conclusions that are directly relevant to clinical practice are presented and updated.

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In particular, this paper schematically addresses three practical questions commonly raised by practicing physicians all across the world [2,3]:

1. Which patients should have ABPM?
2. How to apply and interpret ABPM in daily practice?
3. How to introduce an ABPM service in routine clinical practice?

## WHICH PATIENTS SHOULD HAVE AMBULATORY BLOOD PRESSURE MONITORING ?

The advantages of ABPM are summarized in Box 1 and its limitations in Box 2.

### Indications for ambulatory blood pressure monitoring

Given the strong recommendations worldwide supporting a greater use of ABPM in clinical practice, it is now an important task of National Healthcare Systems to provide ABPM services to patients, who, as a result, will benefit from improved management of hypertension as listed in Box 3.

In clinical practice, the most well established indication for using ABPM is to identify untreated patients who have high BP readings in the office but normal readings during usual daily activities outside of this setting, that is white-coat (or isolated office) hypertension, and to identify varying 24-h BP profiles. The traditional definition of white-coat hypertension is based on an elevated office BP ($\geq$140 mmHg SBP and/or $\geq$90 mmHg DBP) in repeated visits with a BP during the awake period below the currently accepted thresholds for ambulatory daytime hypertension (mean awake ambulatory SBP/DBP $<$135 and $<$85 mmHg in untreated individuals). However, in recent years, there has been increasing interest in BP values during sleep, and nocturnal BP is now recognized to be superior to daytime BP in predicting cardiovascular risk. It seems illogical, therefore, to exclude this period in a definition of white-coat hypertension and the ESH 2013 Position Paper [1] proposes to diagnose this condition also in patients with office readings at least140/90 mmHg and a mean 24-h BP below 130/80 mmHg, thereby incorporating nocturnal BP in the definition (Box 4).

With the prevalence of white-coat hypertension in the community being significantly high (20–25%), it is important to make an accurate diagnosis, which can best be achieved by having 24-h ABPM and/or home BP monitoring (HBPM) done before prescribing antihypertensive drug therapy. The ESH Position Paper recommends that people with white-coat hypertension should have the diagnosis confirmed in 3–6 months and be followed at yearly intervals with ABPM, or HBPM, so as to detect if and when sustained hypertension occurs. It is emphasized that the term white-coat hypertension should be restricted to people who are not on antihypertensive medication.

As with the definition of white-coat hypertension, it is inappropriate to exclude nocturnal BP also when defining masked hypertension, and the definition should be extended to include also 24-h BP values at least 130/80 mmHg together with low office BP (Box 4). Concerning the question as to whether or not the definition of masked hypertension should be applied also to individuals on BP-lowering medication and not only to untreated individuals, it is agreed that the term should not be applied to individuals on treatment, because by definition in treated individuals hypertension has been already diagnosed, and cannot be 'masked' (Box 4). Therefore, the term 'masked uncontrolled hypertension' is proposed as more appropriate for treated individuals. Patients with masked hypertension or masked uncontrolled hypertension should be offered effective therapeutic BP control throughout the 24-h period to prevent the cardiovascular consequences of uncontrolled hypertension.

**Box 1 ADVANTAGES OF ABPM OVER OFFICE BP MEASUREMENTS**

Provides much larger number of readings
Provides highly reproducible average 24-h, daytime and night-time values
Identifies white-coat and masked hypertension phenomena in untreated and treated individuals
Provides a profile of BP behaviour in the individual's usual daily environment
Demonstrates nocturnal hypertension and dipping patterns
Assesses BP variability over the 24-h period
Assesses the 24-h efficacy of antihypertensive medication
Detects excessive BP lowering during 24 h
Is a much stronger predictor of cardiovascular morbidity and mortality

**Box 2 LIMITATIONS OF ABPM**

Limited availability in general practice
May cause discomfort particularly at night
Reluctance to use by some patients especially for repeat measurement
Cost implications (though the cost of devices is reducing, which soon may make ABPM possibly more cost effective than clinic measurements)
Imperfect reproducibility of hourly values
Provision of intermittent measurements in resting rather than fully ambulatory conditions
Possibility of inaccurate readings during activity
Occasional inability to detect genuine artefactual measurements

**Box 3 CLINICAL INDICATIONS FOR ABPM**

**Compelling indications**

*Identifying white-coat hypertension phenomena*
- White-coat hypertension in untreated individuals
- White-coat effect in treated or untreated individuals
- False resistant hypertension due to white-coat effect in treated individuals

*Identifying masked hypertension phenomena*
- Masked hypertension in untreated individuals
- Masked uncontrolled hypertension in treated individuals

*Identifying abnormal 24-h BP patterns*
- Daytime hypertension
- Siesta dipping/post-prandial hypotension
- Nocturnal hypertension
- Dipping status/isolated nocturnal hypertension

*Assessment of treatment*
- Assessing 24-h BP control
- Identifying true resistant hypertension

**Additional indications**

Assessing morning hypertension and morning BP surge
Screening and follow up of obstructive sleep apnoea
Assessing increased BP variability
Assessing hypertension in children and adolescents
Assessing hypertension in pregnancy
Assessing hypertension in the elderly
Assessing hypertension in high-risk patients
Identifying ambulatory hypotension
Identifying BP patterns in Parkinson's disease
Assessing endocrine hypertension

**Box 4 DEFINITION OF WHITE-COAT AND MASKED HYPERTENSION PHENOMENA***

• White-coat (or isolated office) hypertension
Untreated individuals with elevated office BP ≥ 140/90 mmHg**
and 24-h ABP < 130/80 mmHg
and Awake ABP < 135/85 mmHg
and Sleep ABP < 120/70 mmHg
or Home BP < 135/85 mmHg
• Masked hypertension
Untreated individuals with office BP < 140/90 mmHg
and 24-h ABP > 130/80 mmHg
and/or Awake ABP > 135/85 mmHg
and/or Sleep ABP >120/70 mmHg
or Home BP >135/85 mmHg
• Masked uncontrolled hypertension
Treated individuals with office BP <140/90 mmHg
and 24-h ABP ≥ 130/80 mmHg
and/or Awake ABP ≥135/85 mmHg
and/or Sleep ABP ≥120/70 mmHg
or Home BP ≥135/85 mmHg

*Diagnoses require confirmation by repeating ambulatory or home BP monitoring within 3–6 months, depending on the individual's total cardiovascular risk*

***Ambulatory BP values obtained in the office during the first or last hour of a 24-h recording may also partly reflect the white-coat effect ('white-coat' window)*

****Patients with office BP<140/90 mmHg, 24-h BP<130/80 mmHg, awake BP <135/85 mmHg but sleep BP ≥120/70 mmHg should be defined as having 'Isolated Nocturnal Hypertension', to be considered as a form of masked hypertension.*

Masked hypertension might be attributed to isolated nocturnal hypertension, which may be present in 7% of hypertensive individuals and can at present only be diagnosed with ABPM (Box 4).

The Position Paper recommends that ABPM should be performed whenever possible in individuals with suspected hypertension in whom it is necessary to confirm the diagnosis of sustained hypertension, (i.e. to exclude white-coat hypertension), to assess the severity of hypertension throughout the 24-h period, to detect nocturnal hypertension, to detect patterns of BP behavior, such as nondipping and alterations in BP variability (Figs 1–4 and Box 5). ABPM should be performed whenever possible also in already treated hypertensive individuals, to assess effective 24-h BP control with treatment.

### When to repeat ambulatory blood pressure monitoring in clinical practice

The recommendation as to when to repeat ABPM is influenced by so many factors that the issue largely becomes one of clinical judgment and availability of ABPM. For example, severe or apparently resistant hypertension, the presence of target organ damage, the existence of comorbidities, such as diabetes, and a positive family history of premature cardiovascular disease should prompt frequent ABPM in the quest for 24-h BP control, whereas, mild hypertension and the absence of target organ involvement and other features of cardiovascular disease, might call for less frequent ABPM and the use of HBPM.

Specific situations, which may require repeating ABPM at relatively short intervals (3–6 months or even less) include: the need to confirm the diagnosis of white-coat or masked hypertension; confirmation of nocturnal hypertension; follow-up of high-risk patients, especially in the period when optimal treatment is being sought (Box 6).

### Role of home blood pressure monitoring

ABPM and HBPM provide complementary information, and their use should be rationally combined in clinical practice. In most hypertensive patients, out-of-office assessment of BP with HBPM is recommended according to the procedure indicated in the 2008 ESH Home BPM guidelines, by having duplicate morning and evening self-measurements for 7 days and calculating the average BP for 6 days after discarding measurements on the first day [4]. HBPM is particularly suited to long-term follow-up of treated patients because it is cheap and may improve treatment adherence. On the contrary, ABPM is particularly appropriate for the initial evaluation of elevated BP, because it provides standardized and unbiased information within 24 h and without need of training, skills, and commitment from the patient, as required for HBPM. It may also be more useful, if possible in association with HBPM, in those cases when BP control by treatment appears unstable (labile BP values and nocturnal hypertension), in order to ensure adequate 24-h BP control and promote better adherence to prescribed treatment.

A comparison of the different BP measurement methods is shown in Table 1.

### Blood pressure variability

BP is a highly dynamic parameter characterized by continuous fluctuations that include both short-term and long-term variability. While short-term BP variability within 24 h can be readily assessed with ABPM, long-term variability requires repeated BP measurements over days, weeks, or months with repeated measurements of office, HBPM, or ABPM. On the basis of the available evidence, short-term BP variability within 24 h might be considered for risk stratification in population and cohort studies. However, at present it does not represent a parameter for routine use in clinical practice.

## HOW TO APPLY AND INTERPRET AMBULATORY BLOOD PRESSURE MONITORING IN DAILY PRACTICE ?

### Devices and software

Most devices available for ABPM have been validated independently according to the internationally accepted validation protocols, which is essential for clinical use. Specific validation may be required in special patient populations.

With regard to the software presentation and analysis of ABPM data, a standardized single-page report should be provided by all types of monitors, which should present a BP plot with different windows of the 24-h period identified and normal bands clearly demarcated showing the individual's awake and asleep time intervals, summary statistics for BP and heart rate separately for the 24 h, the daytime, the night-time, and the white-coat window periods, the raw BP data, and, optionally,a software-generated interpretative report indicating normal or abnormal BP patterns. The provision of a trend report is useful for follow-up, and the system should store the ABPM data for audit or research, while also facilitating the establishment of registries. ABPM Software requirements are summarized in Box 7.

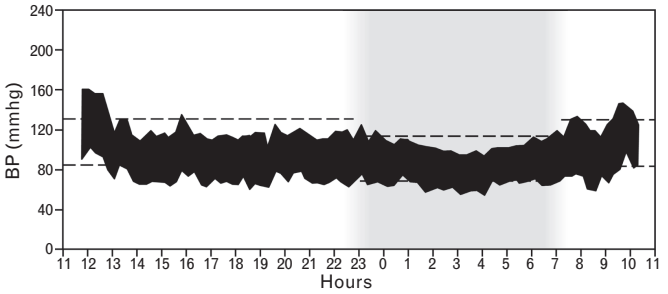


**FIGURE 1** Normal daytime and night-time BP with preserved dipping, and with BP increase only in the 'white-coat' windows at the beginning and the end of the ABP recording. Clinic BP at 160/100 mmHg. Diagnosis: white-coat hypertension.

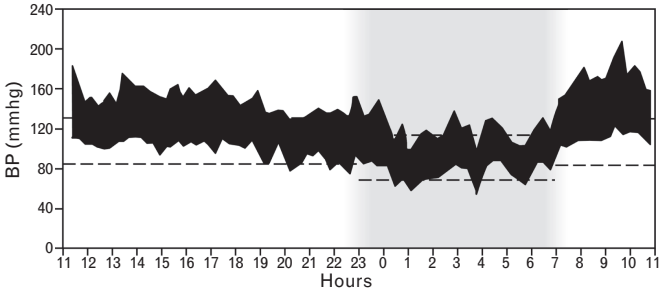


**FIGURE 2** Increased daytime BP particularly during working hours (bus driver) and increased night-time BP with preserved dipping. Clinic BP at 138/88 mmHg. Diagnosis: masked hypertension.

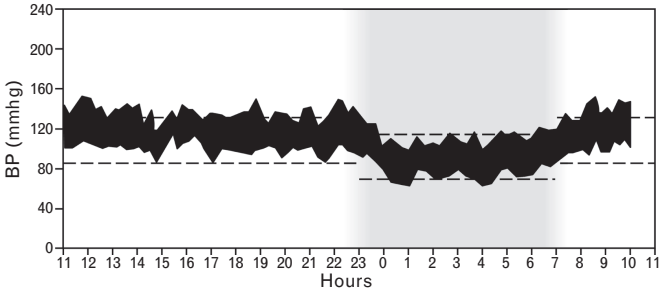


**FIGURE 3** BP constantly elevated during daytime (awake) time, with low night-time (asleep) BP. Clinic BP at 146/86 mmHg. Diagnosis: daytime hypertension with preserved nocturnal BP dipping.

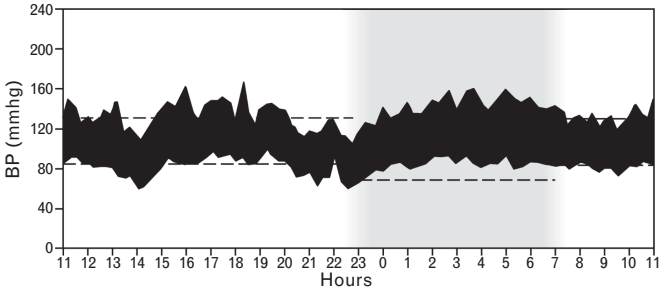


**FIGURE 4** Elevated 24-h ambulatory BP with reverse BP dipping at night (BP rising pattern) in a patient with moderate form of obstructive sleep apnea. Clinic BP at 152/88 mmHg. Diagnosis: non-dipping hypertension.

## Ambulatory blood pressure monitoring thresholds for clinical practice

There is a general agreement on ABPM threshold values for diagnosing hypertension as presented in (Box 8). These levels may be regarded as conservative, and it is acknowledged that further studies are needed to define thresholds more precisely, particularly in high-risk patients. Reference percentiles for ABPM values in children and adolescents are still in need of further investigation, some indications being shown in Table 2, with the 95th percentile representing the threshold for hypertension diagnosis [1].

## Obtaining a satisfactory ambulatory blood pressure monitoring

The requirements for obtaining a satisfactory ABPM are summarized in Box 9.

There are no firm data on which to base recommendations for the number of measurements necessary for a satisfactory ABPM recording. Having considered what evidence is available and the practical issues related to repeating ABPM in practice, it was considered acceptable to have a minimum of 20 valid daytime (awake) measurements and seven measurements at night (asleep), based on the requirement to have at least 70% of measurements being obtained at least every 30 min, or more frequently, throughout the entire 24-h period (Box 10).

## Conditions in which ambulatory blood pressure monitoring may be difficult to perform

### Obese patients

Obesity is a well established major risk factor for hypertension with higher prevalence in specific population groups, such as patients with diabetes mellitus or obstructive sleep apnea. ABPM is often required in these individuals and technical difficulties, such as miscuffing, should not exclude them from such a valuable technology. In such cases, conically shaped cuffs might be used, when available. In patients with very obese arms in whom ABPM cannot be performed, ABPM carried out with the cuff placed on the forearm may be the only means of obtaining a 24-h recording, with an instruction that the wrist must be kept at heart level during measurement, although this possibility requires further investigation.

### Patients with atrial fibrillation

BP measurement in patients with atrial fibrillation is less precise as this type of arrhythmia is accompanied by increased beat-to-beat BP variability due to variations in ventricular filling time, stroke volume, and contractility. Unfortunately, published evidence regarding the role of ABPM in patients with arrhythmias and, specifically in patients with atrial fibrillation, is scarce. In spite of these limitations, and although larger trials in patients on atrial fibrillation are needed, there is no reason at present to exclude such patients from ABPM procedures.

### Children and adolescents

Both European and American recommendations now recognize ABPM as being important for the diagnosis and management of hypertension in children and adolescents, especially for the detection of white-coat and masked hypertension and for the evaluation of nocturnal hypertension, which is often reported in children and adolescents with type-1 diabetes. However, in children, at variance from adults, it is very difficult, if not impossible, to validate diagnostic reference values based on morbidity and mortality. Therefore, reference values for normal and high office and ambulatory BP have been developed from the distribution of BP readings. Although only scanty data are available on this issue, and further research is needed, an example of such thresholds is provided in (Table 2). Cuff dimensions are most important, and the appropriate cuff size should be used according to arm length (4×8, 6×12, 9×18, and 10×24 cm, to cover 80–100% of the individual's arm circumference) and width (40% of the arm circumference).

**Box 5 PATTERNS OF DISRUPTED DIURNAL BP VARIATION IDENTIFIED BY ABPM**

• *Dipping*: Nocturnal systolic and diastolic BP fall >10% of daytime values or
Night/day systolic and diastolic BP ratio < 0.9 and > 0.8
*Normal diurnal systolic and diastolic BP pattern*
• *Reduced Dipping*: *Nocturnal systolic and/or diastolic BP fall from 1 to 10% of daytime values or
Night/day systolic and/or diastolic BP ratio <1 and >0.9
*Reduced diurnal systolic and/or diastolic BP pattern*
*Associated with increased cardiovascular risk*
• *Non-dipping and rising*: No reduction or increase in nocturnal systolic and/or diastolic BP or
Night/day systolic and/or diastolic BP ratio ≥ 1
*Associated with increased cardiovascular risk*
• *Extreme dipping*: Marked nocturnal systolic and/or diastolic BP fall >20% of daytime systolic and/or diastolic values or
*Night/day systolic and/or diastolic BP ratio <0.8*
*Debatable association with cardiovascular risk*
• *Nocturnal hypertension*: Increased absolute level of night time systolic and/or diastolic BP (≥ 120/70 mmHg)
*Associated with increased cardiovascular risk - may indicate obstructive sleep apnoea*
• *Morning surge*: Excessive systolic and/or diastolic BP elevation rising in the morning
*Definitions, thresholds and prognostic impact debatable*
**The classic definition of non-dipping (nocturnal systolic and/or diastolic BP fall <10% or Night /day ratio > 0.9) may be criticized because it includes 'reduced dipping' as a form of 'non-dipping'. Although imprecise, this definition may be clinically justified, however, as both conditions are associated with increased cardiovascular risk*

**Box 6 WHEN TO REPEAT ABPM IN CLINICAL PRACTICE**

*Recommendations on when to repeat ABPM are based on many factors, including clinical judgment and ABPM availability.*
Indications for ABPM repetition to evaluate 24-h BP control:
• Severe or apparently resistant hypertension
• Presence of target organ damage
• Existence of comorbidities (e.g. diabetes)
• Positive family history of premature cardiovascular disease
Indications for ABPM repetition at short time intervals (3–6 months or less):
• To confirm the diagnosis of white-coat or masked hypertension
• Confirmation of nocturnal hypertension
• Follow-up of high risk patients when optimal treatment is sought
In cases of mild hypertension and low cardiovascular risk, ABPM may be repeated at 1 or 2-year intervals, while regular implementation of HBPM may better suit the needs of long-term follow-up.

**TABLE 1. Characteristic features of, and information provided by different blood pressure measurement techniques**

| Characteristic features of measurement | OBPM | HBPM | ABPM |
|---|---|---|---|
| General features | | | |
| Cost | Inexpensive | More expensive than OBPM but cheaper than ABPM | More expensive than OBPM or HBPM but cost-effective |
| Medical requirements | Conventional technique in clinical environment (medical supervision) | Should be used under medical supervision (often this is not the case) | Must be used and interpreted under medical supervision |
| Need for training | Doctors and nurses should be trained and tested for competence | Minimal medical training required but patients should receive instructions | Training required but software can facilitate process |
| Duration of procedure | Brief depending on number of measurements recorded | Home BP should be measured as average of $\times 2$ morning and evening readings for 7 days, first day discarded | Usually 24-h BP measurements at 15–30-min intervals during day and night with minimal requirements of 70% successful readings and 20 daytime and 7 night-time measurements |
| Validated accuracy | Automated devices replacing mercury sphygmomanometers | Many devices on the market have not been independently validated for accuracy | Most ABPM devices on the market have been successfully independently validated for accuracy |
| For accuracy of all devices see: www.dableducational.org, www.bhsoc.org; www.pressionearteriosa.net, www.ESHonline.org | | | |
| Identification of BP patterns | | | |
| Systo-diastolic hypertension | Commonest diagnosis | Better assessment of severity | Allows assessment of severity over 24 h |
| Isolated systolic hypertension | SBP $\geq$ 140 and DBP $<$90 mmHg | SBP $\geq$ 135 and DBP $<$85 mmHg | 24-h ABPM SBP $\geq$ 130 and DBP $<$80 mmHg |
| Isolated diastolic hypertension | SBP $<$140 and DBP $\geq$ 90 mmHg | SBP $<$135 and DBP $\geq$ 85 mmHg | 24-h ABPM SBP $<$ 130 and DBP $>$ 80 mmHg |
| Prediction of outcome | | | |
| Target organ damage, cardiovascular morbidity and mortality | Has been the measure of outcome in the past | Superior to OBPM | Superior to OBPM and stronger evidence than with HBPM |
| | | | Nocturnal hypertension may be sensitive predictor |
| Provision of indices of 24-h BP and HR behavior | | | |
| | Not applicable | Not applicable | Can be computed from ABPM recordings |
| Measures of BP and HR variability | | | |
| | Visit-to-visit BP and HR variability | Day-to-day BP and HR variability | 24-h BP and HR variability |
| Guide to drug prescribing | | | |
| Efficacy of treatment over time | Poor guide because of white-coat response and limited BP readings | Moderate guide to daytime efficacy that can be readily repeated | Allows assessment of efficacy over 24-h period |
| Nocturnal BP control | Not applicable | Preliminary data with ad hoc HBM tools | Allows assessment of nocturnal lowering of BP |
| Reduction of morning surge | Not applicable | Not applicable, but morning BP can be assessed | Allows assessment of treatment effect on morning BP surge |
| To improve compliance to treatment | May have a minor influence | Major documented advantage of HBPM | Provision of ABPM record to patient may be helpful |
| To evaluate drug resistant hypertension | Poor guide because of white-coat response and limited BP readings | Provides better assessment than OBPM but limited evidence | Removes white-coat effect and shows if BP elevation is persistent |
| Identification of hypotensive patterns | | | |
| Overall | Limited because of infrequency of measurement | Better than OBPM | Allows detection of hypotensive episodes throughout the 24-h period |
| Postural hypotension | Difficult to diagnose | Fall in standing HBPM | Time, duration and relationship to hypotension can be documented |
| Postprandial hypotension | Difficult to diagnose | Fall in HBPM after meals | Fall in ABPM after meals |
| Drug-induced hypotension | Difficult to diagnose | Can be detected if HBPM after drug ingestion | Time, duration and relationship to drug intake can be documented |
| Idiopathic hypotension | Difficult to diagnose | Can be detected if HBPM related to hypotension | Best diagnosed with ABPM |
| Autonomic failure | Difficult to diagnose | Not detectable | Daytime hypotension and nocturnal hypertension, increased BP variability |

ABPM, ambulatory blood pressure monitoring; BP, blood pressure; HBPM, home or self-blood pressure monitoring; IDH, isolated diastolic hypertension; ISH, isolated systolic hypertension; OBPM, office blood pressure measurement. Many of the above features of ABPM become of even greater relevance in high-risk patients, such as diabetic patients and in the elderly, who may have complex patterns of 24-h BP and nocturnal hypertension. Modified from [1], by permission.

**Box 7 ABPM SOFTWARE REQUIREMENTS**

**Essential clinical report (one-page report)**
- ABPM analysis and report should be standardized independent of the monitor type
- Standardized plot of all the BP measurements with daytime and night-time windows and normal BP bands demarcated
- Average systolic, diastolic BP and heart rate to be displayed
- Nocturnal BP decline (%) for systolic and diastolic BP
- Summary statistics for time-weighted average systolic and diastolic BP and heart rate for the 24-h period, daytime (awake) and night-time (asleep), with standard deviations and number of valid BP readings
- Facility for showing error readings if required

**Optional requirements**
- Automated software generated interpretative report indicating the normal or abnormal ABPM patterns and whether the requirements for a valid recording are fulfilled
- Facility to plot heart rate and mean BP
- Trend report for comparing repeated ABPM recordings
- Ability to centrally host data

**Research report**
- Data storage and raw data export capability for research analysis and audit
- Parameters include variability measures (such as 24-h SD, 24-h weighted SD, average real variability, coefficient of variation), area under the curve calculations, BP load parameters, rate-pressure product, trough and peak levels, smoothness index (the last two parameters requiring ABPM data before and during treatment to be available), cusum-derived statistics, ambulatory arterial stiffness index (AASI), etc.

**Box 8 THRESHOLDS FOR HYPERTENSION DIAGNOSIS BASED ON ABPM**

24-h average SBP/DBP $\geq$ 130/80 mmHg
Daytime (awake) average SBP/DBP $\geq$ 135/85 mmHg
Night-time (asleep) average SBP/DBP $\geq$ 120/70 mmHg

**Box 9 REQUIREMENTS FOR A SATISFACTORY ABPM**

**Basic requirements**
- Patients must be capable of understanding the procedure and coping with the device
- ABPM should be performed preferably on a routine working day
- Repeat ABPMs should be on like days (routine working or recreational)
- 10–15 minutes needed to program and fit the device, depending on first or follow-up recording

**Fitting the monitor**
- Enter patient details into monitor
- Initialize monitor
- Select frequency of measurement—15–30 min for day and night
- Inactivate measurement LCD display
- Apply cuff to non-dominant arm
- Choose appropriate cuff with bladder length to encircle 80–100% of arm circumference
- Centre of bladder should be over the brachial artery
- Place cuff on bare arm with tubing passing upwards around patient's neck to be connected to the monitor on the waist
- Perform trial measurement to check working and familiarize patient with the monitor

**Advice to the patient**
- Procedure should be explained and instructions printed on a diary card on which time of drug intake, time of going to bed and rising and any symptoms may be recorded
- Patients should be told to follow their usual daily activities but to remain still during measurement with the arm relaxed at heart level
- Instruct patient to place monitor on the bed or beneath the pillow at night
- Warn patient not to take a shower or bath
- Advise patient not to drive but if this is necessary to stop if possible during measurement
- Mark the brachial artery so that if the cuff becomes loose the patient can refit it
- Instruct patient how to switch off the monitor in case of malfunctioning, such as repeated inflation

**Removing the monitor**
- Usually removed by operator after 24–25 h but patients can be instructed to remove and switch off the monitor and send it to the operator's centre
- Connect the monitor to computer and download the data
- If minimum requirement not met (see Box 10), ABPM should be repeated though sub-optimal data can be helpful.

# HOW TO INTRODUCE AN AMBULATORY BLOOD PRESSURE MONITORING SERVICE IN ROUTINE CLINICAL PRACTICE

## Who should perform ambulatory blood pressure monitoring service?

Despite the large diversity in the structure of healthcare systems across different countries, the vast majority of hypertensive patients are being managed in primary care. Thus, primary care doctors may establish their own ABPM service, or alternatively they may refer their patients to an external ABPM service, as they routinely do for multiple other medical tests. Models to develop such services are being currently tested in several countries and might

**TABLE 2. Tables of percentiles for ABP (systolic/diastolic) values in children and adolescents**

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| | Day | | Night | | Day | | Night | |
| Height (cm) | 90th | 95th | 90th | 95th | 90th | 95th | 90th | 95th |
| 120 | 122/80 | 125/82 | 103/61 | 106/63 | 118/80 | 120/82 | 103/63 | 106/65 |
| 125 | 122/80 | 125/82 | 105/61 | 108/63 | 119/80 | 121/82 | 104/63 | 107/66 |
| 130 | 122/80 | 126/82 | 106/62 | 110/64 | 120/80 | 122/82 | 106/63 | 108/66 |
| 135 | 123/80 | 126/82 | 108/63 | 111/65 | 120/80 | 123/82 | 107/63 | 109/66 |
| 140 | 123/80 | 126/82 | 109/63 | 113/65 | 121/80 | 124/82 | 108/63 | 110/66 |
| 145 | 124/79 | 127/81 | 111/64 | 114/66 | 123/80 | 125/82 | 109/63 | 112/66 |
| 150 | 125/79 | 128/81 | 112/64 | 116/66 | 124/80 | 126/80 | 110/63 | 113/66 |
| 155 | 127/79 | 130/81 | 113/64 | 117/66 | 125/80 | 128/82 | 111/63 | 114/66 |
| 160 | 129/79 | 133/81 | 114/64 | 118/66 | 126/80 | 129/82 | 111/63 | 114/66 |
| 165 | 132/80 | 135/82 | 116/64 | 119/66 | 127/80 | 130/82 | 112/63 | 114/66 |
| 170 | 134/80 | 138/82 | 117/64 | 121/66 | 128/80 | 131/82 | 112/67 | 115/71 |
| 175 | 136/81 | 140/83 | 119/64 | 122/66 | 129/81 | 131/82 | 113/63 | 115/66 |
| 180 | 138/81 | 142/83 | 120/64 | 124/66 | – | – | – | – |
| 185 | 140/81 | 144/84 | 122/66 | 125/66 | – | – | – | – |

From [1], by permission.

**Box 10 EVALUATION OF ABPM DATA**

**Definition of daytime and night-time**
- Daytime and night-time intervals are best defined using sleeping time reported by individual users' diary cards (awake and asleep periods)
- Fixed narrow time intervals may be applied by discarding transition periods between daytime and night-time (e.g. daytime defined as 0900–2100 h and night-time 0100–0600 h), provided that there is no daytime sleep (siesta) during ABPM

**Editing and requirements**
- Editing is not necessary for calculating average 24-h, daytime and night-time values
- The ABPM should be repeated if the following criteria are not met
  - 24-h recording with at least 70% of expected measurements
  - At least 20 valid awake and seven valid asleep measurements
  - At least two valid daytime and one valid night-time measurement per hour for research purposes

include specialist clinics, healthcare providers in the private sector, pharmacy based services, and other solutions. Whereas primary care practices and hypertension centers will be the main providers of ABPM, the valuable role of pharmacies in achieving improved control of hypertension is now recognized and may provide a means of making ABPM more accessible to patients.

## Cost and availability of ambulatory blood pressure monitoring

A number of authorities recommend ABPM as a cost-effective investigation, based mainly on the fact that the procedure identifies white-coat hypertension and may prevent patients with a transient rise in BP from being prescribed BP-lowering drugs.

Until recently, ABPM has been generally cited as being more expensive than other measurement techniques, although it has been shown that ABPM is cost-effective, both in specialist services and in primary care. ABPM is particularly cost-effective for the diagnosis and management of newly diagnosed hypertension. The ready provision of ABPM in primary care is dependent on reimbursement to physicians or other healthcare providers by the national healthcare systems or by private insurance and varies considerably from country to country with many countries not providing any reimbursement.

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### Conflicts of interest

Conflicts of interest declarations can be found on the Journal website, http://links.lww.com/HJH/A367.

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