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WHEN TO USE AND HOW TO INTERPRET AMBULATORY BLOOD PRESSURE MONITORING FINDINGS

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SUMMARY – Ambulatory blood pressure monitoring (ABPM) is a noninvasive diagnostic method performed for 24-48 hours, along with daily activities and during sleep, thus being highly useful in cases where the need of antihypertensive medication should be evaluated, in patients with suspected white coat hypertension, nocturnal hypertension, hypertension resistant to combined therapy, and those with borderline hypertension. ABPM helps in the evaluation of the prescribed therapy effects, hypotension, autonomic dysfunction, hypertension in pregnancy, in the elderly and type 1 diabetics, as well as in elucidation of syncopal states and "accidental" hypertension. With appropriate use of ABPM the optimal therapeutic effect can be achieved and the risk of arterial hypertension sequels assessed.

Key words: *Blood pressure monitoring; Hypertension – diagnosis; Hypertension – etiology; Hypertension – prevention and control; Cardiovascular diseases – prevention and control*

Introduction

Blood pressure (BP) measurement is a basis for the diagnosis, treatment as well as epidemiologic and clinical studies of arterial hypertension. BP measurement by standard mercury sphygmomanometer is the most commonly used method in daily clinical routine. Due to the great BP variability as measured by this method, it is not always possible to get a comprehensive insight into the mean values and range of BP in an individual, therefore the cardiovascular risk assessment also being less precise.

In some patient groups, occasional BP measurements at physician office or self-measurements at home cannot be considered representative BP values. Therefore, these patient groups (e.g., white coat hypertension, borderline hypertension, assessment of antihypertensive therapy efficacy, refractory hypertension, etc.) require ambulatory blood pressure monitoring (ABPM) that provides an overview of arterial pressure values over 24-48 hours. This measurement offers necessary data on circadian BP patterns during usual daily activities and in common patient setting, on the rate of BP elevation above the normal values, and on the aBP curve pattern according to the time of the day and use of antihypertensive drugs[1-9].

On making the diagnosis of arterial hypertension and/or assessment of therapeutic efficacy of particular antihypertensive agents it should be borne in mind that the values of systolic BP as measured by ABPM are by 10-15 mm Hg lower, and those of diastolic BP by 5-10 mm Hg lower than those measured by standard mercury sphygmomanometer[6-9].

The aim of this article is to indicate when to use ABPM and how to correctly interpret the results obtained by ABPM.

Normal Values of Arterial Pressure Depend on the Mode and Method of Measurement

Appropriate measurement of BP is the first and most important procedure on making the diagnosis of arterial hypertension. Irrespective of the method of BP measurement, the instrument should be supported by rec-

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ommendations from independent professional societies, regularly calibrated, while BP measurement should be done by use of a cuff of appropriate dimensions. Before the measurement, the patient should be informed on the measuring technique and importance of compliance with some simple rules that may considerably contribute to the measured value accuracy. Accurately measured values of BP have diagnostic and prognostic relevance. Inappropriate measurement may produce false positive or false negative results, which in practice may entail unnecessary therapy to be prescribed in some patients while treating hypertensive patients with inadequately aggressive therapy. If left untreated, arterial hypertension increases the risk of myocardial infarction, stroke, cardiac and renal failure, peripheral vascular disease, and other associated complications several times[1-9]. For example, continuous BP elevation above 140/90 mm Hg is known to be associated with a 6-fold risk of stroke[10].

Normal values of BP vary according to the mode of measurement: home blood pressure monitoring, measurement at physician office or in hospital setting, and ABPM[1-3,7-9,11]. Borderline values of BP defining arterial hypertension at particular mode of measurement are listed in Table 1.

Table 1. Borderline values for definition of arterial hypertension according to method of blood pressure measurement[11]

Method of measurement	Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)
Home self--measurement	135	85
Outpatient /inpatient office	140	90
ABPM*	125	80

*ambulatory blood pressure monitoring

Home pressure monitoring or BP self-measurement is a relatively inexpensive procedure demonstrated to better predict the clinical course and outcome than the measurements performed at office by use of mercury sphygmomanometer, still considered the "gold standard" of BP measurement. Home BP monitoring should only be performed with the instruments approved by professional societies[1,8,9,12,13]. Only five instruments for BP self-measurements with arm cuff (Omron HEM-705CP, HEM-722P, HEM-735CP, HEM-713-CP and HEM-737 Intellinsense) and none with wrist cuff have been granted such approval[12,13]. This method of BP measurements also has both advantages and shortcomings, however, these will be addressed in another study.

Based on the 2005 Practice Guidelines of the European Society of Hypertension for clinic, ambulatory and self-measurement[1], the BP classification presented in Table 2 has been proposed.

Table 2. Arterial pressure values obtained by ambulatory blood pressure monitoring (ABPM) according to time of the day[1]

Time of day	Optimal blood pressure (mm Hg)	Normal blood pressure (mm Hg)	Elevated blood pressure (mm Hg)
Awake	<130/80	<135/85	>140/90
Sleep	<115/65	<120/70	>125/75

Ambulatory Blood Pressure Monitoring

ABPM is a noninvasive diagnostic method of programmed, automated BP measurement over 24-48 hours that minimally interferes with the patient's daily activities, thus contributing to the objectivity of the data obtained. BP measurement is performed by auscultatory or oscillometric technique by use of light and silent automated monitor with a cuff adjusted to the patient's upper arm. Prior to instrument placement according to standardized procedure, the patient is informed by a trained nurse/medical technician on the purpose and mode of BP measurement, emphasizing the role of collaboration for acquisition of high quality and useful measurement results. All patients receive verbal and written instructions on the usual activities during ABPM and their recording in a log-book. It should be stressed that on each BP measurement the arm with the cuff must be kept strictly still[14].

In case of auscultatory ABPM, a microphone placed under the cuff is used to record Korotkoff sounds, known for more than 100 years now. This method of ABPM is advantageous for being less sensitive to arm movements; however, its disadvantage is higher sensitivity to background noise. The main shortcoming of the other mode of ABPM measurement by oscillometric method, is its sensitivity to movements. With both methods, BP values are periodically measured by a monitor, usually every 15-30 minutes during the day, and every 20-45 minutes during the night. The measured BP values are automatically recorded by microprocessors and subse-

quently processed by the respective software. The advantages and drawbacks of ABPM are presented in Table 3.

Table 3. Advantages and shortcomings of ambulatory blood pressure monitoring (ABPM)[1,4,7]

Advantages	Shortcomings
Multiple blood pressure measurements during 24 hours	Price
Real time blood pressure recording with daily activities	Limited device availability
Identification of white coat hypertension	Interference with daily activities
No placebo effect	Lack of valid data and therapeutic guidelines
Better correlation with target organ lesion than with other methods of blood pressure measurement	Lack of long-term comparison studies between ABPM and conventional methods of blood pressure measurement

It should be noted that studies performed to date found no statistically significant sex difference in the rate of incorrect measurements[15], nor did measurement performance differ between outpatients and inpatients[16]. Obviously, one of the main preconditions for highly precise results is proper patient information on this simple procedure and compliance with instructions

Table 4. Approved auscultatory and oscillometry devices for ambulatory blood pressure monitoring (ABPM)[12,13]

Auscultatory monitors	Oscillometric monitors
CH-DRUCK	A&D Instruments TM 2421, TM 2430
Schiller BR-102	SpaceLabs 90207, 90217
ES-H531	IEM Mobil O Graph
DIASYS integra	Meditech ABPM-04
Profilomat	SunTech Medical Oscar 2, AGILIS

on the measurement. Reliable results require not only full compliance with the instruction but also the use of monitors approved by professional societies (Table 4), e.g., British Hypertension Society[12], dabl®Educational Trust[13], Association for the Advancement of Medical Instrumentation, European Society of Hypertension, etc.

By use of ABPM the exact mean of measured BP values is obtained, which is very helpful for precise assessment of cardiovascular risk. In addition, the method offers an array of other data that may prove useful on making the diagnosis, estimating arterial hypertension severity, and follow up of therapeutic effect. ABPM finding provides an insight into BP variability (mostly expressed as standard deviation), pulse pressure, and shape of the BP curve and maximal amplitude. In normal individuals, BP declines by 10% (dipper) during overnight sleep. If this decline is smaller, it is referred to as non-dipper pattern, which is frequently found in secondary forms of arterial hypertension. The overnight BP fall by more than 20% denotes a non-dipper pattern, which may be associated with autoimmune dysfunction or due to inappropriate choice of therapy. Both patterns carry an increased cardiovascular risk. The shape of the curve indicates the possible presence of an abrupt morning pressure peak that is associated with the risk of sudden cardiovascular and cerebrovascular events. The data thus obtained can also point to the possible presence of white coat hypertension. Based on data obtained in outpatient/inpatient conditions and by ABPM, individuals can be classified into the following groups: normotension (normal BP values measured at physician office and normal mean 24-h ABPM values; hypertension (elevated BP values at physician office and elevated mean ABPM values); white coat hypertension (elevated BP values at physician office and normal mean ABPM values); and

Table 5. Patient classification according to BP values[1,4,7,17]

Group	Blood pressure (mm Hg)	Mean 24-h ABPM* value (mm Hg)
Normotension	<140/90	<125/75
Hypertension	>140/90	>125/75
White coat hypertension (isolated clinical hypertension)	>140/90	<125/75
White coat normotension (reverse hypertension)	<140/90	>125/75

*ambulatory blood pressure monitoring

white coat normotension (normal arterial pressure values at physician office and elevated mean ABPM values)[1,4,7,17] (Table 5).

While the phenomenon of white coat hypertension has become an established clinical term known to be associated with an increased cardiovascular risk, an inverse phenomenon has also been recognized for some time now, requiring additional elucidation and evaluation of its clinical relevance.

Ambulatory Blood Pressure Monitoring – When and Why?

ABPM should be performed for diagnosis re-evaluation and to make definitive decision on the appropriate treatment, primarily if white coat hypertension is suspected, in patients with borderline or oscillating arterial hypertension, or in case of unsatisfactory BP control in spite of prescribed therapy. As deterioration of end organ lesions correlates better with ABPM results than with those obtained by other standard office measurements, thus better predicting potential cardiovascular events and mortality in high risk patients requiring strict BP control, ABPM also finds application in patients with a history of acute myocardial infarction, stroke, those on hemodialysis and in diabetic patients[1,4,7,17-22]. Cardiovascular risk assessment in hypertensives based on ABPM is illustrated in Fig. 1.

ABPM is especially useful in identifying the hypertensives in whom the usual nocturnal BP decline fails to occur (non-dipper) because this patient group have a poorer life prognosis than other patients due to the higher incidence of systolic and diastolic left ventricular dysfunction. ABPM is an important source of information on BP pattern in real time with usual daily activities, which is important in patients suspect of orthostatic hypotension. ABPM is also advised in pregnant women at an increased risk of eclampsia for a more precise diagnosis[19-22]. Clinical indications for ABPM according to the latest Practice Guidelines of the European Society of Hypertension[1] are presented in Table 6.

Table 6. Clinical indications for ambulatory blood pressure monitoring (ABPM)[1]

Positive indications	Potential indications
Suspected while coat hypertension	Elderly patients
Suspected nocturnal hypertension	Assessment of antihypertensive effect
Suspected white coat normotension (or masked hypertension)	Diabetes mellitus type 1
Daily curve assessment (dipper/non-dipper /extreme-dipper)	Evaluation of orthostatic hypotension
Refractory hypertension	Autonomic dysfunction
Hypertension in pregnancy	

The use of ABPM in every hypertensive patient is limited by economic resources and performance of the device. Also, the method is unnecessary to use as a diagnostic tool in patients with clear, definitive diagnosis, however, it can always prove useful in the evaluation of therapeutic effect. The algorithm of ABPM use in daily practice is presented in Fig. 2.

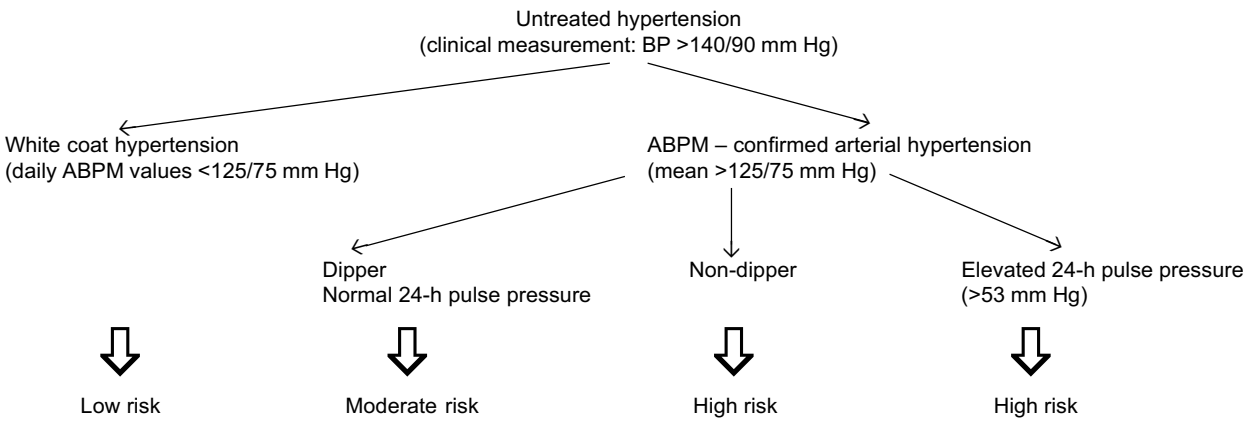

Fig. 1. Cardiovascular risk grading in hypertensives based on ambulatory blood pressure monitoring[19].

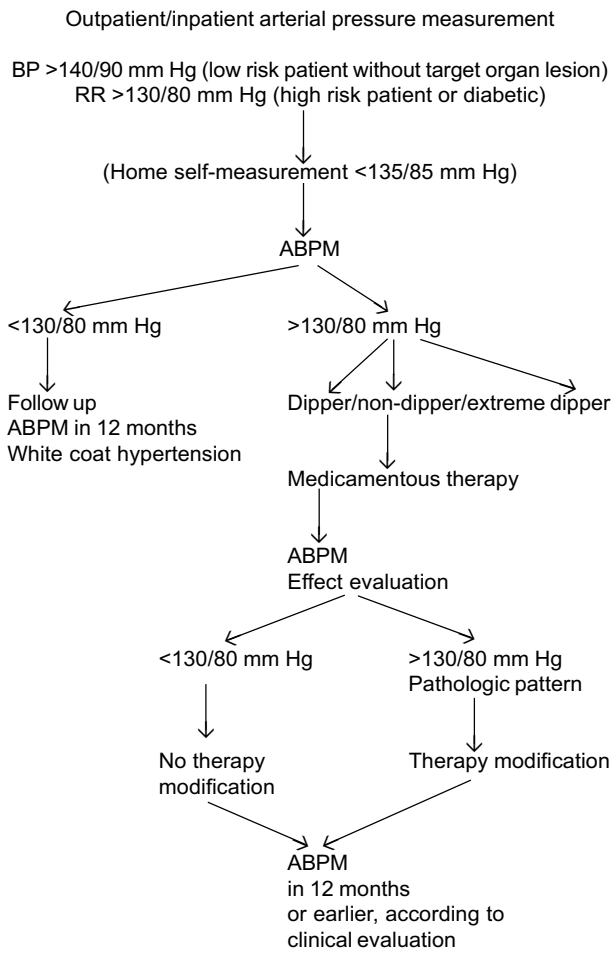

Fig. 2. Algorithm of diagnostic and therapeutic approach to patient based on am bulatory blood pressure monitoring (ABPM)[22]

The Cost-Benefit Aspect of Ambulatory Blood Pressure Monitoring

ABPM is more expensive than the conventional methods of BP measurement; however, the cost proves justified by the benefits it offers. As 15%-35% of individuals treated with antihypertensive agents have white coat hypertension, while an erroneous diagnosis of arterial hypertension can be ruled out by this method, the cost of unnecessary drugs outweighs the cost of ABPM. The real cost of ABPM has been conveniently illustrated by Yarows *et al.*[23], who analyzed the cost of treatment of arterial hypertension patients in the state of Michigan, USA. The annual cost of antihypertensive treatment *per* patient was 578.40 USD *vs.* 188 USD for ABPM. If the measurements were performed in each patient, this would greatly increase the cost due to the high prevalence of arterial hypertension. However, if ABPM were performed in patients suspect of white coat hypertension, i.e. in patients with elevated BP values obtained in the outpatient/inpatient setting, yet free from signs of target organ lesions or other cardiovascular risk factors, and with negative family history of hipertension, the cost of ABPM would be significantly reduced. According to the results reported by Željković-Vrkić *et al.*[24], the prevalence of white coat hypertension in the group of patients with essential hypertension is 29.9%. If the diagnosis of white coat hypertension were made by ABPM in all subjects, the cost of medicamentous therapy would be reduced by almost one-third. There is no need to emphasize that the unnecessary exposure to the possible therapeutic side effects would thus be obviated in one-third of patients. In Croatia, the price of ABPM is 270 HRK for insurees of the Croatian Institute of Health Insurance (battery cost not included), whereas in the USA it is 100-350 USD. Until recently, the cost of this diagnostic procedure was not covered by many insurance companies in the USA, considering its benefit questionable. The fact that ABPM has frequently been performed by use of devices that have not been approved by professional societies must have contributed to such opinion. This probably accounts for the method of ABPM being less commonly employed in the USA as compared with other, especially European countries, where the price is not the predominant limiting factor.

Conclusion

The detection and management of arterial hypertension, currently a major public health problem, are of paramount importance for long-term prevention of cardiovascular and cerebrovascular complications, and premature mortality in particular. When performed by use of a reliable instrument approved by respective professional societies, ABPM provides a more comprehensive insight into the BP pattern than measurements performed by standard mercury sphygmomanometer and home devices for self-measurement. Appropriate utilization of this diagnostic method results in a rational cost-benefit ratio between test price and optimal treatment of the patient.

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Sažetak

KADA PRIMIJENITI I KAKO TUMAČITI NALAZ KONTINUIRANOG MJERENJA ARTERIJSKOG TLAKA

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Kontinuirano mjerenje arterijskog tlaka (KMAT) je neinvazivna dijagnostička metoda koja se primjenjuje tijekom 24-48 sati uz obavljanje uobičajenih dnevnih aktivnosti i spavanja, pa je njezina korist dokazana u slučajevima gdje treba prosuditi nužnost primjene antihipertenzivnih lijekova, kod osoba sa sumnjom na hipertenziju bijelog ogrtača, noćnu hipertenziju, hipertenziju otpornu na kombiniranu terapiju te u bolesnika s graničnom hipertenzijom. KMAT pomaže i u procjeni učinka propisane terapije, procjeni hipotenzije, autonomne disfunkcije, hipertenzije u trudnica, starijih osoba i dijabetičara tipa 1, kao i u razjašnjavanju sinkopalnih stanja te "slučajnih" hipertenzija. Pravilnom uporabom KMAT postiže se optimalan učinak terapije i procjenjuje opasnost od posljedica arterijske hipertenzije.

Ključne riječi: *Motrenje krvnog tlaka; Hipertenzija – dijagnostika; Hipertenzija – etiologija; Hipertenzija – prevencija i suzbijanje; Srčanožilne bolesti – prevencija i suzbijanje*