ASH Position Paper: Home and Ambulatory Blood Pressure Monitoring
When and How to Use Self (Home) and Ambulatory Blood Pressure Monitoring

Thomas G. Pickering, MD, D Phil;[1] William B. White, MD;[2] on behalf of the American Society of Hypertension Writing Group

The American Society of Hypertension will publish a series of Position Papers in their official journals throughout the coming months. The following Position Paper originally appeared: JASH. *2008;2(3)119–124 and is reprinted here with permission of the publisher.*

The accurate measurement of blood pressure (BP) remains the most important technique for evaluating hypertension and its consequences, and there is increasing evidence that the traditional office BP measurement procedure may yield inadequate or misleading estimates of a patient's true BP status. The limitations of office BP measurement arise from at least 4 sources: (1) the inherent variability of BP coupled with the small number of readings that are typically taken in the doctor's office; (2) poor technique (eg, terminal digit preference, rapid cuff deflation, improper cuff and bladder size); (3) the white-coat effect (the increase in BP that occurs in the medical care environment), and (4) the masked effect (a decrease in BP that occurs in the medical care environment that may lead to undertreatment; in the case of masked hypertension, the out-of-office BP is hypertensive, while the resting, in-office BP is normotensive or substantially lower than the out-of-office BP).

Nearly 70 years ago, there were observations made that office BP can vary by as much as 25 mm Hg between visits.[1] The solution to this dilemma is potentially 2-fold: improving the office BP technique (eg, using accurate, validated automated monitors that can take multiple readings) and using out-of-office monitoring to supplement the BP values obtained in the clinical environment.

Out-of-office monitoring takes 2 forms at the present time: self–(or home) BP monitoring and ambulatory BP monitoring (ABPM). While both modalities have been available for 30 years, only now are they finding their way into routine clinical practice. The use of self–BP monitoring (also referred to as home BP monitoring) as an adjunct to office BP monitoring has been recommended by several national and international guidelines for the management of hypertension, including those of the European Society of Hypertension,[2] the American

From the Center for Behavioral Cardiovascular Health, Columbia Presbyterian Medical Center, New York, NY;[1] and the Division of Hypertension and Clinical Pharmacology, Pat and Jim Calhoun Cardiology Center, University of Connecticut School of Medicine, Farmington, CT[2]
Address for correspondence: Dr. William B. White, Pat and Jim Calhoun Cardiology Center, University of Connecticut Health Center, 263 Farmington Avenue, Farmington, CT 06030-3940
E-mail: wwhite@nso1.uchc.edu

doi: 10.1111/j.1751-7176.2008.00043.x

Society of Hypertension,[3] the American Heart Association (AHA),[4] the British Hypertension Society,[5] the European Society of Hypertension,[6] the Japanese Hypertension Society,[7] the World Health Organization–International Society of Hypertension,[8] and the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.[9] In the United States, the use of self–BP monitoring is growing rapidly: Gallup polls suggest that the proportion of patients who report that they monitor their BP at home increased from 38% in 2000 to 55% in 2005. In contrast, the use of ABPM in clinical practice remains limited, although exact numbers are not available.

Techniques of Out-of-Office Monitoring

Ambulatory BP monitors are used only by physicians' offices. They require preprogramming to take readings at preset intervals (typically every 15–30 minutes) throughout the day and night. They are reasonably accurate and are lightweight ($\leq$1 lb). The majority of patients can obtain a full profile of BP and its variability over 24 hours. The hardware and software of ABPM devices have changed little during the past decade. Since the costs of ABPM have not been covered well by third-party payers, their use has been limited in clinical practice. Medicare has granted reimbursement for ABPM, but only for the limited indication of suspected white-coat hypertension with an absence of target organ damage; in our experience, this payment is typically less than the true cost of the procedure. Other insurers are becoming more liberal in reimbursing for ABPM, but prior authorization is the rule rather than the exception.

Self-monitoring (home) BP devices have undergone substantial changes during the past decade. The first generation were aneroid devices that were handheld and required manual inflation and deflation. These devices are now rarely used and have been replaced by automated oscillometric devices, which take single readings that are displayed on a liquid crystal display screen. The more basic devices do not have memory or a printer, so patients are required to keep a written log of their BP readings. The accuracy with which patients obtain and write down the BP readings has been found to be questionable.[10] Monitors that have been formally validated have been found to be reasonably accurate, but many marketed self-monitoring devices have not been formally tested. As self-monitoring devices are readily available for purchase by patients and are inexpensive, their use has increased rapidly over the past decade. Freestanding devices, such as those found in pharmacies, may not be regularly maintained and may not be reliable.

The newest generation of self/home BP monitors has the same BP measurement technique as older devices but has increasingly sophisticated electronics. Many devices have memory so that they can easily compute the average values of the BP. Some will automatically take 3 readings at fixed intervals (eg, 1 minute) following one press of a button. The latest models can be programmed to take readings at preset times, which might include periods of sleep. With this exception, the ability to record the nighttime pressure has been the exclusive domain of ambulatory monitors, and there is increasing evidence that nighttime pressure is an independent predictor of cardiovascular risk.[11] The ability of programmable self/home BP monitors could make nighttime readings more practical, although experience is limited at present.

The more sophisticated self/home BP monitors are distinctly more expensive than the currently available ones, and it is not clear whether they will be optimally used. Some patients will purchase these more expensive devices for self-use, but it is also possible that physicians will purchase these recorders and charge patients a modest fee for a diagnostic evaluation. This might include a week's worth of morning and evening readings plus a number of nighttime readings. The monitors often have models with different sized cuffs—the inflatable part of the cuff should cover at least 80% of the circumference of the upper arm. About half of the users may need a large cuff.

CLINICAL AND SCIENTIFIC BACKGROUND

Self-monitoring and ABPM can provide unique information that may be of help both for making treatment decisions and for evaluating the response to treatment (Table). The mainstay for the justification of both procedures is that there is steadily increasing and substantial evidence that both measures give a better prediction of risk than does office BP measurement. This has been shown in numerous studies using ambulatory BP measurements[11–18] and in several using self-monitoring of the BP.[18–21] In general, when there is a discrepancy between the office BP and the out-of-office BP, the risk follows the latter more closely. Thus, patients with white-coat hypertension (high office BP and normal out-of-office BP) are at relatively low risk,[17] while patients whose out-of-office BP is higher than anticipated from the office BP are at relatively high risk.[15] This latter condition has been referred to as masked, or hidden, hypertension on the grounds

Table. Comparison of Office BP, Ambulatory BP, and Self-Monitored (Home) BP

	Office BP	Ambulatory BP Monitoring	Self-BP Monitoring
Predicts events	Yes	Yes	Yes
Diagnostic utility	Yes	Yes	Yes
Detects white-coat and masked hypertension	No	Yes	Yes (limited)
Evaluates the circadian rhythm of BP	No	Yes	No
Evaluates therapy	Yes	Yes (limited repeat uses)	Yes
Normal limit for average-risk patients, mm Hg	140/90	130/80 (24-hour), 135/85 (awake), 120/75 (sleep)	135/85
Cost	Low	High	Low
Reimbursement	Yes	Partial	No

Abbreviation: BP, blood pressure.

that it is not normally detected by conventional office BP measurements.[22] Even in treated hypertensive patients, high out-of-office BP is a marker for increased risk.

Due to its inherent variability, using a small number of readings yields poor reproducibility for the BP level. By increasing the number of readings used to calculate the average BP, both self-monitoring and 24-hour ABPM give much better estimates of the average. In one study,[23] home BP was the most reproducible (lowest standard deviation of the differences between sets of measurements: 6.9/4.7 mm Hg for systolic and diastolic pressures for self-measurement, 8.3/5.6 mm Hg for ambulatory BP, and 11.0/6.6 mm Hg for office BP). Self-measured BP readings may be more reproducible than ambulatory BP readings if they are taken under more standardized conditions.

Deciding When to Use Ambulatory and Home BP Monitoring

BP measured over 24 hours by ambulatory recording is the best method for estimating an individual's cardiovascular risk related to hypertension. This has been established in a large number of prospective cohort studies,[11–17] most of which have shown that the office BP has negligible prospective value if the 24-hour BP is known. There are fewer prospective studies using home BP,[18–21] and only 2 have compared ambulatory and self–BP monitoring (the Ohasama[14,19] and Pressioni Arteriose Monitorate E Loro Associazioni [PAMELA] studies).[18] Both of these studies found that the 2 methods had similar predictive value for future cardiovascular events. In principle, one would expect that 24-hour ambulatory BP would give a better prediction of risk, since there are important aspects of the circadian profile of BP that are detected by ambulatory recordings but not by self/home BP measurement. These include BP variability, the morning surge of BP, and the related measures of dipping and the nocturnal BP.[24] Numerous studies have claimed that the nondipping pattern (a diminution or reversal of the normal fall of BP during the night) and high nighttime BP predict risk independently of the 24-hour level; other studies have not confirmed this.[24] At the present time, there are no official guidelines relating to the interpretation of these additional measures, and a 24-hour BP value of 130/80 mm Hg and a self/home BP value of 135/85 mm Hg are the useful cutoffs for patients in whom antihypertensive therapy is being considered.[24,25] In the highest-risk population, there are no official guidelines defining the ambulatory BP and self-monitoring equivalent of an office BP value of <130/80 mm Hg.

An area in which ABPM is particularly useful and superior to self–BP monitoring is the evaluation of the efficacy of antihypertensive drugs in clinical trials.[26–28] In clinical practice, however, clinic and self-monitoring of the BP are the preferred methods for the clinical evaluation of responses to treatment, since performing multiple ABPM sessions in the same patient is impractical.

Practical Considerations and Recommendations

Finding the Appropriate Monitor for Self-Measurement. For both ambulatory and self–BP monitoring, use of the upper arm is recommended.[4] While wrist monitors are popular for self–BP monitoring by patients, they are generally not recommended. Wrist monitors are limited by the need to hold the device very still at the level of the heart; however, in patients with very large upper arms, wrist monitors may be the only practical method. Finger devices are not reliable.

It is essential that only monitors that have been independently validated for accuracy according to a

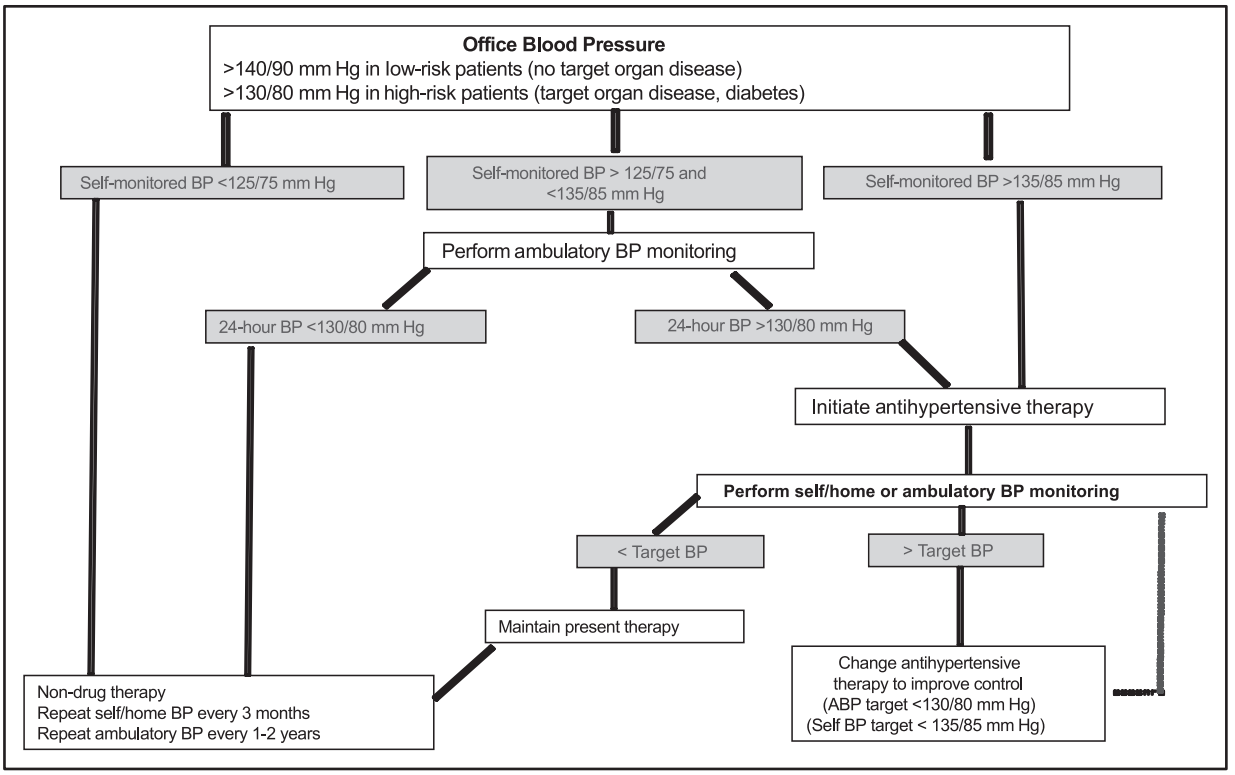

Figure. Practical use of self/home blood pressure (BP) monitoring and ambulatory BP (ABP) monitoring in clinical practice. Self-BP monitoring should be performed according to strict guidelines prior to clinical decision making (see text for details). Following antihypertensive therapy, the determination to use self/home BP monitoring vs ABP monitoring is made according to availability, clinical judgment, and insurance coverage.

well-established protocol be utilized. This is of particular relevance to self–BP monitors, because there are many such devices on the market that have not been independently tested. An updated list of validated monitors is available on the dabl Educational Trust Web site (http://www.dableducational.org). Manufacturers frequently change the model numbers of self–BP monitoring devices, making it hard to know whether the validation results still apply. To remedy this, manufacturers are now being asked to sign a declaration of BP measuring device equivalence.

Means to Utilize Self/Home BP Monitoring in Clinical Practice. It is of utmost importance to educate patients in the proper use of their prescribed self/home BP devices. An appropriate cuff size should be selected based on arm circumference according to AHA guidelines for small, adult, and large adult cuff and bladder assemblies.[4,29] Patients should be instructed to perform their readings in the seated position (both legs on the floor, back supported, and arm supported at heart level) after resting for 5 minutes. Three readings should be taken in succession (at 1-minute intervals) both first thing in the morning (prior to taking any antihypertensive drugs) and in the evening (prior to dosing of any antihypertensive drugs, if taken at that time). Duplicate readings taken in the morning and evening for 1 week and recorded and averaged will yield self/home BP values that can be utilized for diagnostic and therapeutic purposes.[29] Standing BP values can be obtained when indicated, for instance in diabetic autonomic neuropathy, when orthostatic symptoms are present, or when a dose increase in antihypertensive therapy has been made.

Using ABPM in Clinical Practice. While ABPM is not widely available in primary care practice, it is generally offered by centers specializing in hypertension or cardiovascular medicine. Ambulatory BP measurement has particular utility in detection of masked hypertension, white-coat hypertension, and assessment of antihypertensive therapy responses in patients receiving complex antihypertensive treatment regimens. As noted previously, ABPM is also the most effective means to determine BP values

during sleep when nocturnal hypertension or nondipping profiles are suspected. Ambulatory monitoring studies should be performed on typical working days if the patient is employed; during the daytime it is advisable that the patient refrain from sleeping, performing vigorous exercise, and spending long periods of time driving (motion artifact). Diaries or journals documenting times of wakefulness and sleep as well as timing of antihypertensive medication doses are useful for interpretation of the data.

The ambulatory BP devices may not work well in some patients with very irregular cardiac rhythms including atrial fibrillation or in patients with rigid arteries such as those receiving dialysis. In these individuals, the BP values should be compared to values obtained with auscultatory devices when the clinician is uncertain.

A schema showing how both self/home and ambulatory BP measurements may be used in clinical practice is shown in Figure. Self–BP monitoring may be used as an initial step to evaluate out-of-office BP, and if ABPM is available it is most helpful in cases in which the self/home BP is borderline (between 125/75 and 135/85 mm Hg).[27,29,30] The target value for self/home BP is usually 135/85 mm Hg for those whose target office BP level is 140/90 mm Hg and 125/75–130/80 mm Hg for those whose target office BP level is 130/80 mm Hg.[29] Equivalent values for ambulatory BP in low-risk hypertensive patients are 130/80 mm Hg for 24-hour BP, 135/85 mm Hg for the awake BP, and 125/75 mm Hg for the sleep BP.[4]

Acknowledgments: This article was reviewed by ***Giuseppe Mancia, MD****, and* ***Sheldon G. Sheps, MD****. The American Society of Hypertension Writing Group Steering Committee: Thomas D. Giles, MD, chair; Henry R. Black, MD; Joseph L. Izzo Jr, MD; Barry J. Materson, MD, MBA; Suzanne Oparil, MD; and Michael A. Weber, MD.*

References

1 Ayman D, Goldshine AD. Blood pressure determinations by patients with essential hypertension. I. The difference between clinic and home readings before treatment. *Am J Med Sci*. 1940;200:465–474.

2 O'Brien E, Waeber B, Parati G, et al. Blood pressure measuring devices: recommendations of the European Society of Hypertension. *BMJ*. 2001;322(7285):531–536.

3 Pickering T. Recommendations for the use of home (self) and ambulatory blood pressure monitoring. American Society of Hypertension Ad Hoc Panel. *Am J Hypertens*. 1996;9:1–11.

4 Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the subcommittee of professional and public education of the american heart association council on high blood pressure research. *Circulation*. 2005;111:697–716.

5 Williams B, Poulter NR, Brown MJ, et al. Guidelines for management of hypertension: report of the fourth working party of the British Hypertension Society, 2004-BHS IV. *J Hum Hypertens*. 2004;18:139–185.

6 Mancia G, De Backer G, Dominiczak A, et al. Guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Eur Heart J*. 2007; 28:1462–1536.

7 Imai Y, Otsuka K, Kawano Y, et al. Japanese society of hypertension (JSH) guidelines for self-monitoring of blood pressure at home. *Hypertens Res*. 2003;26:771–782.

8 World Health Organization-International Society of Hypertension guidelines for the management of hypertension. *J Hypertens*. 1999;17:151–183.

9 The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*. 2003;289(19): 2560–2572.

10 Mengden T, Chamontin B, Phong Chau NG, et al. Chanudet X and the participants of the First International Consensus Conference on Self-Blood Pressure Measurement. User procedure for self-measurement of blood pressure. *Blood Press Monit*. 2000;5:111–112.

11 Dolan E, Stanton A, Thijs L, et al. Superiority of ambulatory over clinic blood pressure measurement in predicting mortality: the Dublin outcome study. *Hypertension*. 2005;46:156–161.

12 Perloff D, Sokolow M, Cowan R. The prognostic value of ambulatory blood pressures. *JAMA*. 1983;249:2792–2798.

13 Verdecchia P, Porcellati C, Schillaci G, et al. Ambulatory blood pressure. An independent predictor of prognosis in essential hypertension. *Hypertension*. 1994;24:793–801.

14 Ohkubo T, Imai Y, Tsuji I, et al. Prediction of mortality by ambulatory blood pressure monitoring versus screening blood pressure measurements: a pilot study in Ohasama. *J Hypertens*. 1997;15:357–364.

15 Bjorklund K, Lind L, Zethelius B, et al. Isolated ambulatory hypertension predicts cardiovascular morbidity in elderly men. *Circulation*. 2003;107:1297–1302.

16 Clement DL, De Buyzere ML, De Bacquer DA, et al. Prognostic value of ambulatory blood-pressure recordings in patients with treated hypertension. *N Engl J Med*. 2003;348:2407–2415.

17 Kario K, Pickering TG, Umeda Y, et al. Morning surge in blood pressure as a predictor of silent and clinical cerebrovascular disease in elderly hypertensives: a prospective study. *Circulation*. 2003;10:1401–1406.

18 Mancia G, Facchetti R, Bombelli M, et al. Long-term risk of mortality associated with selective and combined elevation in office, home, and ambulatory blood pressure. *Hypertension*. 2006;47:846–853.

19 Ohkubo T, Imai Y, Tsuji I, et al. Home blood pressure measurement has a stronger predictive power for mortality than does screening blood pressure measurement: a population-based observation in Ohasama, Japan. *J Hypertens*. 1998;16:971–975.

20 Bobrie G, Chatellier G, Genes N, et al. Cardiovascular prognosis of "masked hypertension" detected by blood pressure self-measurement in elderly treated hypertensive patients. *JAMA*. 2004;291:1342–1349.

21 Stergiou GS, Baibas NM, Kalogeropoulos PG. Cardiovascular risk prediction based on home blood pressure measurement: the Didima study. *J Hypertens*. 2007; 25:1590–1596.

22 Pickering TG, Eguchi K, Kario K. Masked hypertension: a review. *Hypertens Res*. 2007;30:479–488.
23 Stergiou GS, Baibas NM, Gantzarou AP, et al. Reproducibility of home, ambulatory, and clinic blood pressure: implications for the design of trials for the assessment of antihypertensive drug efficacy. *Am J Hypertens*. 2002; 15:101–104.
24 Pickering TG, Shimbo D, Haas D. Ambulatory blood-pressure monitoring. *N Engl J Med*. 2006;354:2368–2374.
25 Mansoor GA, White WB. Self-measured home blood pressure in predicting ambulatory hypertension. *Am J Hypertens*. 2004;17:1017–1022.
26 White WB. Ambulatory Blood Pressure Monitoring for the Assessment of Antihypertensive Therapy in Clinical Trials. In: White WB (ed). *Blood Pressure Monitoring in Cardiovascular Medicine and Therapeutics*. Totowa, NJ: Springer-Verlag/Humana Press, Ltd; 2007:437–462.
27 White WB, Giles T, Bakris GL, et al. Measuring the efficacy of antihypertensive therapy by ambulatory blood pressure monitoring in the primary care setting. *Am Heart J*. 2006;151:176–184.
28 White WB, Mansoor Ga, Pickering TG, et al. Differential effects of morning and evening dosing of nisoldipine ER on circadian blood pressure and heart rate. *Am J Hypertens*. 1999;12:806–814.
29 Pickering TG, Miller NH, Ogedegbe G, et al; American Heart Association; American Society of Hypertension; Preventive Cardiovascular Nurses Association. Call to action on use and reimbursement for home blood pressure monitoring: a joint statement by the American Heart Association, American Society of Hypertension, and the Preventive Cardiovascular Nurses' Association. *Hypertension*. 2008;52(1):1–9.
30 White WB. Ambulatory blood pressure monitoring in clinical practice. *N Engl J Med*. 2003;348:2377–2378.