Whole-Day Blood Pressure

Principal Discussant

MICHAEL A. WEBER, M.D.

Section of Clinical Pharmacology and Hypertension, Veterans Administration Medical Center, Long Beach, and the University of California, Irvine, California

Case Presentation

Patient 1

A 23-year-old woman was evaluated for hypertension in 1980. Six years previously an autonomous adenoma had been removed during a parathyroid exploration. At operation, her blood pressure ranged between 120/80 and 130/90 mm Hg.

During a routine gynecological examination one year before the evaluation for hypertension, her blood pressure was recorded as 145/90 mm Hg. She was given birth control pills to regulate menstrual irregularity. Four months later, her blood pressure ranged between 150 to 160 mm Hg systolic and 110 to 120 mm Hg diastolic. Subsequent measurements revealed peak systolic blood pressure of 180 mm Hg and peak diastolic blood pressure of 120 mm Hg. Evaluation at that time revealed normal serum electrolyte values, chest roentgenogram, electrocardiogram (ECG), urinalysis results, and 24-hour urinary vanillylmandelic acid excretion. Results of physical examination were normal, and she had no family history of hypertension or arteriosclerotic vascular disease.

The patient was given propranolol, 20 mg twice daily; the dosage later was increased to 40 mg twice daily, and birth control pills were discontinued. She remained on this regimen for 1 year before being evaluated in the hypertension clinic, when her medications were discontinued. Within 6 weeks after therapy was stopped, her diastolic blood pressure was greater than 100 mm Hg and antihypertensive therapy was resumed with nadolol, 40 mg/day. This regimen returned the blood pressure to normal. She continued nadolol therapy for an additional 2 years. Since that time, and without antihypertensive medication, her blood pressure has remained normal, with values ranging from a maximum of 136/86 mm Hg to a minimum of 108/70 mm Hg. Her diet, physical activity, and weight have remained essentially the same during this 6-year period. There has been no evidence of recurrence of hyperparathyroidism nor any symptoms of the multiple endocrine adenoma syndromes.

Patient 2

A 32-year-old woman was initially evaluated in February 1986. Her medical history was notable for mitral valve prolapse. Hypertension was first noted 3 weeks before presentation.

Although she had no history of shortness of breath, nocturnal dyspnea, orthopnea, edema, or angina, there was a strong family history of coronary artery disease. Her father and three of four grandparents had had myocardial infarctions, and her father was known to have hypertension; the blood pressure status of her grandparents was unknown.

She had been taking no medications. Physical examination revealed a fourth heart sound and a grade 2/6 late holosystolic murmur without a click. Both findings were consistent with her history of mitral
valve prolapse. Repeated blood pressure measurements revealed values averaging 160/96 mm Hg, and therapy with timolol, 10 mg twice daily, was started. In addition, the patient stopped smoking, increased her physical activity, and decreased her sodium chloride intake.

Because the patient reported severe lethargy on β-blocker therapy, the dosage of timolol was decreased to 5 mg twice daily. Her blood pressure was 130/80 mm Hg and remained normal for 15 months; therefore, all medications were discontinued. Her blood pressure promptly rose to 170/102 mm Hg, and she was given captopril, 25 mg twice daily. Her blood pressure fell to 134/76 mm Hg within 4 weeks and remained well controlled for 1 year. The dosage was decreased to 12.5 mg twice daily because of the patient’s lethargy. The patient reported a loss of appetite, which spontaneously resolved, but she remained tired and her blood pressure rose to 152/96 mm Hg. The captopril dosage then was increased to 12.5 mg three times per day, and her blood pressure fell to 132/84 mm Hg within 6 weeks. The patient is being maintained on a regimen of captopril, 37.5 mg/day, although she continues to complain of fatigue, which is thought to be due to an endogenous depression.

Case Discussion

These two patients represent different types of problems in mild hypertension. Physicians sometimes are reluctant to diagnose and treat hypertension in young women, possibly through concern over the possible effects of drugs on pregnancies that may subsequently occur. But hypertension is a cardiovascular risk factor at all ages, and if the diagnosis is confirmed, it should be treated. Patient 1 appeared to have borderline hypertension that was subsequently exaggerated by her use of the oral contraceptive. Interestingly, she apparently required active antihypertensive therapy for well over a year after stopping the contraceptive, suggesting that she had a primary underlying hypertension. After 2 further years, however, her treatment was discontinued and her blood pressure then remained normal. It is not easy to explain this outcome. Did she have an exceptionally prolonged hypertensive response to her treatment with the oral contraceptive? Did the antihypertensive drugs produce a permanent remission? Or, with the exception of when she was ingesting the oral contraceptive and perhaps for a period thereafter, is it possible that she was never truly hypertensive but simply had artificially high blood pressure readings during her visits to the clinic? This final possibility could have been examined a few months after discontinuing the oral contraceptive treatment by a more stringent test for hypertension, such as automated whole-day blood pressure monitoring.

Patient 2 also had mild hypertension that appeared to require pharmacological therapy. Of equal importance, she had a strong family history of severe cardiovascular events and hypertension. Thus, the physicians had little choice other than to start antihypertensive treatment and to persist with it despite the complaints of symptomatic side effects. As I will discuss later, collaborative factors such as a strong family history, evidence for target organ involvement, or the presence of other cardiovascular risk factors can often allow a clinical decision to be made without a need for automated blood pressure monitoring.

The measurement of blood pressure by the conventional mercury sphygmomanometer is the standard clinical technique for diagnosing hypertension and following its response to treatment, but the actual methods used for measuring blood pressure in this fashion are poorly defined. Numerous factors can influence the measurement of blood pressure, including the posture of the patient, the time of day, and whether the measurements are made in a hospital, an office, or elsewhere. Yet, the so-called casual blood pressure measurement has been used as the basis for the actuarial data and epidemiological studies that have provided our knowledge of the prognosis and natural history of differing levels of blood pressure. Of course, it is likely that these general conclusions are accurate since they are based on very large numbers of measurements, even though the values in many individual subjects may have been inaccurate or unrepresentative.

In making diagnostic and therapeutic decisions for a single patient, a more reproducible and better defined method might be preferable. Specifically, there seems to be a logic to obtaining blood pressure measurements throughout the day that take into account the full scope of an individual subject’s activities and their effects on blood pressure. In the same way that 24-hour ambulatory ECG monitoring is often more revealing than the conventional ECG or rhythm strip, the whole-day recording of blood pressure could also provide insights not normally obtained by the traditional examination in the physician’s office or clinic.

Available Techniques

The most obvious and direct way to record blood pressure accurately on a continuous basis is by intraarterial recording. It is over 20 years since the first such system was described, although developmental work was needed to refine an ambulatory system for routine investigational use in patients. Despite the accuracy and portability of this system, which requires a miniaturized perfusion pump to preserve the potency of the intra-arterial cannula, the approach has potential disadvantages. Its insertion into the brachial artery requires a small but invasive procedure, and inevitably, there is the concern of leaving patients with indwelling cannulas unsupervised for long periods, especially if they are distant from the clinic. Despite a comparatively large experience with this method and the reports of its safety and practicability, almost all work with ambulatory blood pressure monitoring in the United States has been with noninvasive techniques.

The ambulatory noninvasive systems are usually based on a standard arm cuff that is inflated at predetermined intervals by a small pump unit carried on a shoulder strap or attached to the patient’s belt. There
have been preliminary evaluations of noninvasive equipment that can measure blood pressure in the circulation of the finger or the ear lobe, but these methods are not yet generally available. There are two methods of measuring the blood pressure with the conventional arm cuff: auscultatory or oscillometric. The auscultatory method employs a small microphone placed over the brachial artery (typically under the cuff itself) that listens to the Korotkoff sounds in the same fashion as a human observer with a stethoscope. Some of the available devices use chest ECG leads so that R-wave gating can be employed to ensure that the sounds heard by the microphone are true Korotkoff sounds and not artifacts. The oscillometric method works by perceiving the subtle changes in air pressure within the cuff system, and it is able to discriminate the systolic blood pressure and the mean blood pressure (taken to be the lowest pressure at which the maximum pulse amplitude is maintained); from these two measurements it is then possible to calculate the diastolic blood pressure.

The units contain a memory system that accumulates all the blood pressures measured throughout the 24-hour period. Semiautomatic systems that require the patient to inflate the cuff at intervals throughout the day are also available; although these systems are popular, obviously they are unable to provide blood pressure measurements when the patient is asleep. All the available blood pressure monitoring systems can be interfaced with computers to provide printouts of the whole day’s blood pressure readings together with some preliminary analysis and statistics. The most modern of the blood pressure monitors are light (weight, < 1 kg) and portable and appear to be acceptably accurate when compared with intra-arterial devices or mercury sphygmomanometers.

Validity of Whole-Day Monitoring

One of the principal lines of evidence supporting the physiological relevance of whole-day blood pressure monitoring has been the demonstration of a clear circadian pattern of blood pressure with the use of this technique. Studies with both intra-arterial and noninvasive methods have characterized a definite pattern: Blood pressures during daytime hours, from approximately 0800 to 1800, are essentially at a plateau, although there are two small peaks, one in the midmorning at about 1000 and the other at about 1800. The blood pressure then falls steadily until it reaches a nadir at about 0300, whereafter it rises fairly sharply toward the higher daytime levels. The typical pattern obtained with noninvasive monitoring is shown in Figure 1. Studies comparing normal volunteers with hypertensive patients have shown that both groups have almost identical circadian patterns; the hypertensive patients simply have consistently higher blood pressures than the normal volunteers (Figure 2). The pattern of the heart rate is not parallel to that of the blood pressure; unlike the blood pressure, which starts rising before arousal of the patient, the heart rate remains low until the patient actually awakens. This finding suggests that blood pressure and heart rate might be regulated in somewhat different fashions. The autonomic nervous system probably is a key factor in the blood pressure pattern, for it has been shown that plasma concentrations of both norepinephrine and epinephrine...
have circadian patterns similar to those observed for blood pressure.1

The relationship between blood pressure and left ventricular muscle mass measured by echocardiography represents a second line of evidence for the physiological validity of whole-day blood pressure monitoring. This relationship is based on the assumption that the mass of the left ventricle should be proportional to the blood pressure, either as a reflection of the work of the heart required to sustain a given level of blood pressure or, possibly, because blood pressure and heart size are each dependent on a third factor, such as the activity of the sympathetic nervous system.8 Correlations between left ventricular muscle mass and conventionally measured blood pressure have been comparatively weak, but the whole-day blood pressure average (the mean of all measurements throughout the 24-hour period) has been shown to have a far closer relationship with heart size.9,10 Parenthetically, it should be noted that this relationship probably is valid only in normotensive or mildly hypertensive ranges of blood pressure; the large hypertensive heart may no longer be able to sustain the comparatively severe forms of hypertension that the relationship suggests.11 But, in general, the finding of a superior correlation of left ventricular muscle mass with the whole-day blood pressure value appears to have been accepted as evidence that this technique is physiologically more relevant than the casual blood pressure measurement. Moreover, at least one study has suggested that ambulatory monitoring may be superior to conventional readings in predicting prognosis. In patients followed up for 5 years, cardiovascular death and morbidity rates were found to be highest in patients with mild hypertension whose ambulatory blood pressure values exceeded their office measurements.12

The reproducibility of the 24-hour blood pressure monitoring pattern also appears to support its validity as a physiological measurement. Figure 1 shows data from blood pressure monitoring procedures performed in normal volunteers on two separate occasions. For the group as a whole, there is a strong reproducibility of the whole-day blood pressure from 1 day to another.13 Moreover, not only is the average blood pressure reproducible between separate monitoring periods, but so also is the measurement of the amplitude (difference between highest and lowest readings during the day) and the timing of the highest and lowest values,14 indicating that the overall pattern of the blood pressure is also reproducible.

Studies using intra-arterial measuring techniques have confirmed the repeatability of the circadian pattern for blood pressure monitoring performed on consecutive days as well as for 24-hour periods separated by a 6-week interval.15 Unfortunately, these findings are not true for all individuals. In 21% of normal subjects the 24-hour average systolic blood pressure was found to differ by 10 mm Hg or more between the 2 days of observation, and in 35% of subjects the diastolic blood pressure differed by 5 mm Hg or more.13 These differences could be explained by day-to-day changes in the subjects' activity, especially as the participants in this study were maintaining full work and domestic activities while being monitored.

Should Ambulatory Monitoring Be Truly Ambulatory?

At first sight, ambulatory blood pressure monitoring is an appealing concept. It could be reasoned that blood pressures measured at work, during times of physical or emotional stress, and during recreation and relaxation would provide a more sensitive and meaningful profile of the blood pressure than would conventional readings measured in the office or clinic. But there appears to be a disadvantage to this approach: There are no established criteria for interpreting the data. Careful studies have already shown that blood pressure is higher at work than it is at home, at least for most people.16 It is also known that physical activity and a variety of other stimuli can, quite appropriately, cause temporary increases in the blood pressure. But with a few exceptions, such as medically supervised exercise testing, there are as yet no data that can define what could be termed a "normal" blood pressure response as compared with what might be a "hypertensive" response in a patient allowed unrestricted activity. Patients undergoing ambulatory blood pressure monitoring procedures are often encouraged to keep diaries of events occurring during the study period. Inevitably, these records are often incomplete or go to the other extreme of excessive awareness of every trivial event during the day. Moreover, subjects often are not aware of the possible impact of routine stimuli such as discussions or interruptions that might have an emotional or intellectual impact. If patients are told that they must be meticulous about record keeping, the maintenance of the diary can of itself become one of the chief activities of the day.

Despite the compactness of the more modern monitoring devices, they are still sufficiently intrusive to make patients aware of the blood pressure measurements. Patients often must explain the equipment to their colleagues at work or their friends. This makes it even more difficult for the subject to have a "typical" day. Indeed, as discussed earlier, the 24-hour blood pressure measurements are not always reproducible from day to day in individual patients, very likely because activities on one day may differ from those on another. It is also likely that the analogy of blood pressure monitoring to ambulatory ECG monitoring is not really valid; any major event that occurs with ECG monitoring, regardless of how it is precipitated, potentially is of clinical importance even if the patient is undergoing an unstructured or atypical day's activities. On the other hand, most subjects undergoing ambulatory blood pressure monitoring, including normal volunteers, could be anticipated to have at least a few appropriately high blood pressure measurements during the day.

A partial solution to these problems might be to perform blood pressure monitoring in controlled environments. For example, it has been shown that blood
pressures measured during work hours correlate more closely with echocardiographic left ventricular mass than do blood pressures measured in other settings. But even this approach may be unreliable, for not all patients have their highest readings at work, nor are the work readings always reproducible. There are those whose pressures are highest in the doctor’s office and others who have higher pressures at home.

Ultimately, the complexity of interpreting whole-day blood pressure monitoring data reflects our attempt to measure two separate parameters at one time: the intrinsic characteristics of the patient’s blood pressure and the responsiveness of the blood pressure to environmental and emotional stimuli. It is probably invalid to interpret responses to stimuli in an individual without first obtaining a meaningful baseline reflective of the innate blood pressure pattern and variability. Thus, the argument could be made that activity during whole-day blood pressure monitoring should not be truly ambulatory or spontaneous but instead should be regulated in some systematic way. Ideally, patients should follow a protocol in which there are no unexpected, unusual, or stressful events; later, if desired, the effects of differing environmental stimuli on blood pressure could be observed. Unfortunately, issues of practicality and cost make it unlikely that whole-day blood pressure monitoring in controlled environments will easily become a reality. Nevertheless, the establishment of a standardized and partly restricted program of activity probably would add to the reproducibility of the technique and make its findings more interpretable.

**Short-term Monitoring**

It is tempting to consider the possibility that repetitive blood pressure measurements obtained during periods of just a few hours might be a useful substitute for whole-day monitoring. Because this can be done in the office or clinic, using relatively simple nonambulatory equipment, it can reduce the cost and inconvenience of the whole-day procedure. Moreover, because it can be performed in a standardized environment, concerns about uncontrolled stimuli need no longer apply. My colleagues and I have shown that the averages of blood pressure measurements obtained with automatic equipment at 8- to 10-minute intervals during 2-hour observation periods correlate more closely with the 24-hour averages than do even the most carefully measured conventional readings. Similarly, other investigators using multiple measurements during short-term periods have found strong concordance with 24-hour values. When used in diagnostic studies, the 2-hour method was found to be reasonably similar to the 24-hour method in determining which patients of those previously diagnosed as having hypertension by conventional blood pressure measurements could be verified as being hypertensive.

Short-term repeated blood pressure measurements also may have some of the same physiological relevance as whole-day monitoring. Morning 2-hour averages correlate with echocardiographic measurements of left ventricular mass almost as closely as do 24-hour averages and are superior to casual blood pressure readings. But in other respects the short-term monitoring technique is not an adequate substitute for whole-day observations. It does not allow the physician to gain a clinical impression of what might be excessively high blood pressures in some patients during different portions of the day. Moreover, the important early hours of the morning, between 0300 and 0700, when excessively rapid rises in blood pressure may occur, cannot be evaluated during a short-term monitoring period. Assessment of the duration of action of antihypertensive therapy also cannot be performed with short-term automated blood pressure measurements. On the other hand, in patients with highly variable blood pressures or who are participating in clinical trials, routine 2-hour office blood pressure averages might be more reliable and reproducible than conventional readings in assessing the efficacy of treatment.

**Making a Diagnosis**

Making a diagnosis of hypertension in usual clinical practice appears to be a simple task. With the use of criteria established by the Joint National Committee on the Detection, Evaluation, and Treatment of High Blood Pressure (JNC), it seems necessary only to carefully measure the blood pressure by conventional means on two or three occasions before deciding that a patient’s blood pressure is normal or that a diagnosis of hypertension should be made. Unfortunately, even this approach can lead to unsatisfactory consequences. The Australian Therapeutic Trial of Mild Hypertension is an example. In this study, almost 2000 patients with conventionally measured diastolic blood pressures in the range of 95 to 109 mm Hg were treated with placebo for 3 years so as to provide a control group for patients receiving active medications. By the end of the study, a surprisingly large number of the placebo-treated patients, approximately 40%, had blood pressures in the normotensive range. It is possible that this percentage was relatively inflated because of the withdrawal from the study of patients whose blood pressures had become unacceptably high during the period of observation. Nevertheless, the magnitude of this placebo response, also seen in other therapeutic trials, commands attention. Almost certainly, the majority of patients whose blood pressures became normal during the study were normotensive individuals who had been wrongly diagnosed at the start of the study. Other evidence for misdiagnosis comes from studies of the effects of discontinuing antihypertensive therapy in hypertensive patients. A sizable percentage of patients who discontinued their antihypertensive therapy remained normotensive indefinitely. It is possible, of course, that the therapy attenuated the natural history of the hypertension and gave the appearance of an apparent long-term cure, but again, some of these subjects may not have been truly hypertensive even before the treatment was started.
A further illustration of this problem is shown in Figure 3. We performed whole-day ambulatory blood pressure monitoring in 29 age-matched pairs of men; one member of each pair was a hypertensive patient, and the other was a normal control. Our criterion for a diagnosis of hypertension was a minimum of three conventionally measured diastolic blood pressures greater than 90 mm Hg in our clinic; in fact, most of these patients had been observed to have higher blood pressures on more than three occasions. Yet, as shown in the figure, we found a clear overlap between the hypertensive and the normotensive subjects when we examined their whole-day blood pressure averages. It seems reasonable to conclude that 20 to 30% of the hypertensive patients could not be differentiated from the range of values established by the normal volunteers. Similarly, evaluation of the frequency of abnormal blood pressure readings during the day, as opposed to the simple whole-day blood pressure average, confirmed an overlap between the conventionally diagnosed hypertensive patients and the normotensive subjects (Figure 4).

Many physicians believe intuitively that there is a "white-coat effect" that can explain why blood pressures in the office or clinic are higher than elsewhere. Unquestionably, for some patients, this is true. A study from Europe used continuous intra-arterial blood pressure monitoring to directly assess the effects of the actual act of measuring the blood pressure by physicians with a standard sphygmomanometer. In many patients the continuous intra-arterial measurements revealed a marked rise in blood pressure during the performance of the conventional procedure; indeed, this physician-performed maneuver increased the resting blood pressure by an average of 27/15 mm Hg. Of interest, a later study showed that this apparent pressor effect was of lesser amplitude if nurses rather than physicians performed the measurement procedure.

Studies with noninvasive monitoring techniques also have explored this issue. The data in Figure 5 show the differences between blood pressures measured in the office and those obtained from the average of 24-hour blood pressure measurements in previously diagnosed hypertensive and normotensive individuals. Clearly, there is a trend indicating that for most participants the blood pressure is lower for the day as a whole than it is in the office. But even these findings are somewhat complex. It could be argued that the whole-day blood pressure average is often lower than the office reading simply because (as shown in Figure 1) the whole-day average

![Figure 3](http://hyper.ahajournals.org/)  
**Figure 3.** Average whole-day systolic and diastolic blood pressure values for each of 29 normotensive volunteers and for each of 29 age-matched hypertensive patients. (Reprinted from Drayer and Weber.)

![Figure 4](http://hyper.ahajournals.org/)  
**Figure 4.** Incidence of increased systolic and diastolic blood pressure (BP) values during 24-hour monitoring periods in each of 29 normotensive volunteers and in each of 29 age-matched hypertensive patients. (Reprinted from Drayer et al.)
includes the relatively low values obtained during sleep. In fact, the 24-hour value should be an average of 5 to 8 mm Hg lower than values obtained during the daytime hours.6,19 Thus, Figure 5 reveals a somewhat unexpected finding, for some subjects actually had blood pressures in the office or clinic that were lower than their 24-hour averages. These results suggest that physicians sometimes underestimate the level of blood pressure and that some patients who appear normotensive in the office may be found to be hypertensive if studied by whole-day monitoring. Parenthetically, the difference between daytime and nighttime blood pressures, as shown in Figure 1, could explain the frequent discrepancies between readings obtained by the physicians in the clinical setting and those obtained by patients in their homes; apparently normal readings at home, if obtained in the evening hours, do not necessarily rule out the possibility of hypertension.

The traditional recommendation for diagnosing hypertension has been to perform repeated blood pressure measurements during successive visits to the office. Some persons who appear hypertensive at first will be found to be normotensive once they have become more familiar with the clinical setting. But even this simple approach may be open to question. In a study of young patients whose initially high blood pressure later appeared to be normal, we observed that echocardiographic measurements of left ventricular muscle wall thickness were similar to those in patients with sustained hypertension and were significantly greater than those in subjects whose blood pressures had been consistently normal.8 Thus, some individuals whose blood pressure readings during visits to the office are only occasionally high may represent a subgroup of patients who could benefit from a more rigorous evaluation.

**Criteria for Diagnosis**

Because the relationship between casual blood pressures and the risk of cardiovascular events is continuous, there is no clear dividing line between normal blood pressure and hypertension. Inevitably, arbitrary guidelines such as those recommended by the JNC2 have been used to select levels of blood pressure at which a diagnosis of hypertension should be made. Although whole-day monitoring appears to provide a more reproducible index of blood pressure than do casual measurements, epidemiological data with this newer technique are still limited. Given the relative complexity and expense of whole-day monitoring, it is realistic to assume that there will never be the same breadth of experience with this technique as there has been with casual measurements. It is important to remember, however, that the major role of automated monitoring, when applied to the individual patient in clinical practice, is to improve the reliability of the measurement rather than to redefine the epidemiological and physiological characteristics of blood pressure.

The JNC22 has recommended that hypertension be diagnosed at a conventional diastolic blood pressure of 90 mm Hg. Strictly speaking, the corresponding whole-day average should be slightly less than this value because of the inclusion of the lower nighttime readings, but we have tended to be somewhat conservative and to retain the 90 mm Hg level as our criteria for diagnosis. Alternatively, in reference to Figure 4, a diagnosis of hypertension appears justified in patients in whom over 30% of individual readings throughout the 24-hour period are greater than 90 mm Hg. A similar approach, also derived from the JNC recommendations, can be used for diagnosing systolic hypertension at levels of 140 or 160 mm Hg.

When the 24-hour average blood pressure is used for diagnostic purposes, it is important to ensure that it is based on readings obtained evenly throughout the day; an undue weighting of measurements during certain parts of the day, or the omission of measurements during other parts, could bias the whole-day mean. To avoid or minimize this possibility, we generally first obtain averages during each of the 12 two-hour periods constituting the entire day (as shown in Figure 1) and then secondarily calculate the average of the 12 periods. Occasionally, a 2-hour period is composed entirely or predominantly of artifactual, erroneous, or
omitted readings and thus cannot be used in obtaining the whole-day average. There are two approaches to this problem: An interpolated reading can be derived statistically to provide a value for the "missing" 2-hour period or the whole-day average can be based on the averages of 6 four-hour periods. Because 24-hour monitoring provides so many separate measurements, it is possible statistically to derive a mean and standard deviation of the blood pressure readings for each individual patient. Parameters such as confidence limits can then be described and used to help determine the clinical reliability of the monitoring data. Experience with such approaches, however, is limited. At the present time, we still believe that a validly derived 24-hour blood pressure average, despite its apparent simplicity, appears to provide a sound basis for summarizing the day as a whole.

The data in Figure 2 show that hypertensive patients in general have whole-day blood pressure patterns that are parallel to those found in normal subjects. Thus, it has been difficult to suggest any qualitative appearances of blood pressures throughout the day that might allow the diagnosis of hypertension to be made or excluded. Differences between daytime and nighttime values, for example, can vary quite markedly between patients having similar whole-day averages, but the clinical and therapeutic implications of these differences have not yet been established. Some attempts have been made to use classic chronobiological analytical methods for evaluating the characteristics of blood pressure throughout the day, but no routine diagnostic criteria have been suggested. Occasionally, it is possible intuitively to interpret the overall blood pressure in an individual patient and reach a diagnostic decision, but large-scale experience will be required before diagnostic or therapeutic recommendations can be made based on interpretations more complex than whole-day averages or the percentages of abnormal readings. Occasionally, the results of blood pressure monitoring can be in a borderline range. Under these circumstances, it may be reasonable to defer a treatment decision for several months before reevaluating the patient.

Selecting Patients for Monitoring

For practical and economic reasons it will never be as convenient to perform whole-day blood pressure monitoring as it is to perform a conventional blood pressure measurement. The selection of appropriate patients for this procedure thus becomes an issue. Factors other than high blood pressure can be important in making a clinical diagnosis of hypertension. It is not usually appropriate to perform whole-day blood pressure monitoring if high casual blood pressure measurements are associated with clinical or laboratory evidence of cardiovascular complications, such as fundus changes, coronary disease or cardiomegaly, renal insufficiency or proteinuria. Similarly, a strong family history of hypertension or premature cardiovascular disease helps confirm a conventional hypertension diagnosis. The presence of other risk factors for cardiovascular disease, including smoking, lipid abnormalities, or diabetes mellitus, also can facilitate a therapeutic decision without requiring the confirmatory evidence of whole-day blood pressure monitoring. In general, the monitoring procedure is probably only justified when high blood pressure is an isolated finding and the diagnosis cannot be supported by other clinical or historical findings. Realistically, even in the absence of supportive evidence, casual diastolic blood pressure readings of 110 mm Hg or above should compel a clinical diagnosis of treatment-requiring hypertension in most patients.

A recent consensus conference on indications for ambulatory blood pressure monitoring added a further component to these recommendations: namely, that diagnostic whole-day blood pressure monitoring is only indicated in those patients whose high casual blood pressure readings in the office are in disagreement with normal blood pressures measured in the patient's own home. Unfortunately, excessively conservative approaches to the use of the technique means that most patients whose blood pressures are in the high-normal or borderline range usually will not be monitored and those individuals whose blood pressures in the clinical setting are paradoxically low (as in Figure 5) probably will not be identified.

Furthermore, if there is a 20 to 30% chance that patients undergoing this diagnostic procedure might be found not to need antihypertensive therapy, there could be an overall saving in cost. A lifetime of therapy, including physician visits, laboratory tests, medications, and time that is lost from work, is an expensive undertaking. The savings resulting from the avoidance of treatment in patients found not to be hypertensive likely would more than compensate for the overall costs of performing blood pressure monitoring procedures.

Final Comment

The technological advances that continue to make whole-day ambulatory blood pressure monitoring procedures more convenient and reliable add to the temptation to use this technique more frequently in clinical practice. Although evaluation of antihypertensive efficacy still appears to remain predominantly in the realm of investigational medicine, blood pressure monitoring as a diagnostic tool appears to have much to recommend it. There are legitimate concerns that uncritical overuse of this methodology could add considerably to the costs of providing care to patients, and it will be necessary to adhere to guidelines such as those discussed earlier to ensure that this diagnostic tool is used appropriately. But it is also clear that conventional approaches to diagnosing hypertension are often erroneous and can lead to unnecessary therapy and the wasting of resources. More work remains to be done in standardizing methods for blood pressure monitoring and in better defining criteria for its interpretation, but, used thoughtfully, it has already become a valuable and cost-effective diagnostic tool.
Questions and Answers

Dr. Gordon H. Williams (Brigham and Women's Hospital): You have made the point that some patients who appear to be hypertensive when their blood pressure is measured by conventional means no longer have this diagnosis when they are examined by the continuous monitoring technique. What criteria are you using to reach this conclusion? Are you simply saying that some patients whose diastolic blood pressures are 90 mm Hg or above by the conventional measurement have averages below 90 mm Hg with the monitoring? Should we have a different level of blood pressure at which hypertension should be diagnosed when we use this new technique?

Dr. Weber: There is no consensus as yet as to the level of blood pressure that should be used as a diagnostic criterion when using the whole-day blood pressure average to evaluate individual patients. Probably we should use a value closer to 85 mm Hg than to 90 mm Hg, for in most individuals the whole-day average is approximately 5 mm Hg lower than their conventional office readings. Thus, it is possible that when we use 90 mm Hg as our criterion we are still overdiagnosing hypertension.

Dr. Joseph A. Majzoub (Brigham and Women's Hospital): You have said that you would be less likely to perform blood pressure monitoring in a patient who has a family history of cardiovascular disease or who has other risk factors. Is this because you think it is more likely that the patient has hypertension, or is it simply that the risk associated with a misdiagnosis would be lower in a patient with that kind of history?

Dr. Weber: At the present time we are still very selective in the use of blood pressure monitoring. There are probably some patients with a strong family history of cardiovascular problems in whom an initial diagnosis of hypertension could be ruled out by blood pressure monitoring, but since I would usually be more aggressive in my desire to start treatment in a patient with a strong family history or other risk factors, I would be more willing to make a clinical decision in such a patient than in patients who lack corroborative findings to go along with their casual high blood pressures.

Dr. Williams: Patient 1 was placed on a regimen of birth control pills soon after casual blood pressure readings were noted to be elevated. Would you now consider her to be a person who has an additional risk factor and therefore does not need diagnostic blood pressure monitoring?

Dr. Weber: This patient's treatment with the oral contraceptives started at an unfortunate time. If it had been delayed, further conventional blood pressure measurements might have revealed her blood pressure to be normal. If not, that would have been an appropriate time to perform blood pressure monitoring. But once treatment with the oral contraceptives had begun, her pressures became so high that she was unquestionably hypertensive. At that stage, all that could be done was to stop the oral contraceptives, wait for a reasonable period until their effects had worn off, and then perform the monitoring procedure if the casual pressure still remained high.

Dr. Robert G. Dluhy (Brigham and Women's Hospital): You have mentioned that between 20 and 25% of patients with high blood pressures in the office seem to be normotensive when studied with blood pressure monitoring. Is this finding confined to patients with just mild or moderate hypertension? At what level of blood pressure in the office do you feel that the diagnosis of hypertension is so probable that treatment should be started without first performing blood pressure monitoring?

Dr. Weber: Our experience in monitoring patients with more severe forms of hypertension is limited. Some patients with casual diastolic blood pressures in the range of 110 to 120 mm Hg have had substantially lower whole-day averages when tested with blood pressure monitoring, but usually they still have remained within a hypertensive range. Most of the patients shown to be normotensive during whole-day monitoring have had office blood pressures in the mild range, typically 90 to 105 mm Hg. I think that a patient whose carefully measured casual diastolic blood pressures are 110 mm Hg or above need not be subjected to monitoring.

Dr. Thomas J. Moore (Brigham and Women's Hospital): The epidemiological studies such as the Framingham Study have helped to define the variations in cardiovascular risk associated with differing levels of casual blood pressures. This has allowed us to establish some guidelines for deciding which patients should be treated. How can we use data produced by blood pressure monitoring for this purpose?

Dr. Weber: Some critics, perhaps concerned by potential overuse of this technique, have claimed that it is premature to use whole-day blood pressure monitoring in the clinical setting until "normalcy" and "hypertension" have been defined. But I believe that this is an unfair criticism, because this differentiation has not even been established with the use of conventional blood pressure measurements. As we all know, the relationship between blood pressure and cardiovascular risk forms a continuum. The JNC22 has recommended that a level of 90 mm Hg be employed as a dividing line. But this suggestion, useful as it may be, is still arbitrary. Ultimately, a diagnostic decision should be based on all the available clinical information and not solely on the level of blood pressure itself. At present, the purpose of long-term automated blood pressure monitoring is not to redefine hypertension or its relationship to risk, but simply to provide a more accurate and reproducible measurement of the blood pressure.

Dr. Williams: Did you use systolic blood pressure as a diagnostic criterion in your studies? As you know,
there is a growing awareness that systolic blood pressure is a powerful predictor of risk at all ages, but it is especially important in the elderly. One of the problems with measuring systolic blood pressure in older patients in the office or clinic is that the readings are often quite variable.

Dr. Weber: Most of the published work with whole-day blood pressure monitoring has focused primarily on diastolic blood pressures. This is probably because most of the published criteria based on standard measurements of blood pressure have used diastolic pressures for diagnosing and classifying hypertension. With whole-day monitoring, however, we have confirmed the clinical observation that systolic blood pressure is quite variable during the day, especially in older individuals. Some recent research has suggested that variability of blood pressure during the day may be at least as important as its absolute values as a predictor of target organ involvement. If this observation is confirmed, blood pressure monitoring might become especially useful in predicting cardiovascular risk in older target individuals.

Dr. Harold S. Solomon (Brigham and Women’s Hospital): I have used ambulatory blood pressure monitoring in a number of my own patients. I have never had difficulty in making a useful clinical interpretation of the data. I feel that useful information, in support of both treatment and withholding treatment, has been gathered by this new technique without any scientific proof of validity. It has been especially useful in patients who claim that their blood pressure readings at home or in other places away from the office are lower than the values that I have measured. Both my patients and I have been surprised at times at how low their blood pressures can be during typical daily activities. I realize that more research should be done to define characteristics in the population and to evaluate effects of therapy. But even at this stage, I have found that blood pressure monitoring has been helpful in making clinical decisions in individual patients.

Dr. Weber: The decision to diagnose or to treat hypertension, as with many other conditions, ultimately reflects the judgment of the physician. Even with blood pressure monitoring, there are still patients in whom a diagnosis or a therapeutic decision is challenging. We should not forget that other diagnostic techniques can be helpful. For example, echocardiography and Doppler studies can sometimes discriminate early evidence for hypertensive structural or functional changes in the left ventricle, even in patients with mild hypertension whose ECGs and other clinical findings appear normal. Obviously, the presence or absence of evidence for early target organ involvement would be of value in deciding whether to start treatment.

References


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M A Weber

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