

## ACC POSITION STATEMENT

### Ambulatory Blood Pressure Monitoring\*

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A previous policy statement by the American College of Cardiology (ACC) on automated blood pressure monitoring (approved December 13, 1985 and reapproved in 1990) made recommendations for the use of ambulatory blood pressure monitoring in patients with hypertension, but this technology was considered to be "investigational" and not yet "clinically applicable" because of problems with the accuracy and convenience of devices and issues related to cost and fear of abuse. These concerns have been addressed in published reports, and the Hypertensive Diseases Committee of the American College of Cardiology now recommends ambulatory blood pressure monitoring as a mature, clinically applicable (useful) technology for the management of selected hypertensive patients.

#### Devices and Technology

Ambulatory blood pressure monitoring is a noninvasive technique by which multiple indirect blood pressure readings can be obtained automatically for periods of 1 to 3 days with minimal intrusion into the daily activities of the patient (1). The devices are automatic, lightweight and quiet and use auscultatory or oscillometric methods, or both, to determine blood pressure. Some auscultatory devices are coupled to an electrocardiogram for the purpose of gating the R waves to the Korotkoff sounds and reducing error from noise artifact. Solid state equipment is currently available that analyzes the ST segment and rhythm (Holter) as well as the blood pressure measurements. Recent comparisons of different ambulatory devices and techniques generally reveal considerable agreement among devices in general (2-4). The user

must apply the ambulatory blood pressure monitoring equipment with particular attention to technical details. Rigorous assessment of agreement with a standard sphygmomanometer in the lying, seated and standing positions is necessary with each individual subject (1). Agreement of sequential readings to within  $\pm 5$  mm Hg of systolic and diastolic readings, both at the beginning and end of the ambulatory record, permit the reasonable extrapolation that the intervening blood pressures are valid. Most of the devices are inaccurate when the cardiac rhythm is irregular, such as atrial fibrillation or frequent ectopic beats. However, these situations are usually recognized at the outset because comparison with a standard manometer is difficult or impossible to achieve.

Patient acceptance of this equipment is excellent at the present time. The devices are very safe. Petechiae and edema distal to the cuff rarely may occur, particularly in patients with vascular fragility or platelet dysfunction. Dermatitis and ulnar nerve palsy have been reported, but these complications are very unusual (1). Usually, the patient is asked to keep a detailed activity journal that includes information about physical and mental activity, meals, sleep, medication and other life events to assist in the interpretation of the blood pressure data. The validity of the data is analyzed first by computer and then carefully reviewed by the user.

Standards that specifically address ambulatory blood pressure monitoring are now available (3,5,6). The 1992 standard of the Association for the Advancement of Medical Instrumentation (AAMI)\* on Evaluation of Automatic Blood Pressure Devices (5,6) recommends validation of an automatic electronic device by comparison with either direct, intraarterial blood pressure measurements or preferably to the noninvasive cuff-stethoscope technique, based on Korotkoff sounds. It contains detailed recommendations for populations to be tested, for methods of comparison, statistical analysis of the data, presentation of the results and criteria for acceptability. Similar recommendations have been approved by the British Hypertension Society in their

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standards document as well (3). Users considering a purchase, as well as instrument designers, should refer to these standards for the detailed requirements.

### Relation of Ambulatory Blood Pressure Monitoring to Office Blood Pressure and Hypertensive Disease

Blood pressure in normotensive subjects is characterized by a clear circadian pattern. Blood pressure values tend to peak during the daytime hours and then fall to a nadir after midnight. In the early morning hours with awakening and resuming activities, blood pressure sharply increases, with daytime levels being reached within a relatively short period (7). Activity of subjects at the time of blood pressure recording is an important determinant of the level of blood pressure and may affect hypertensive disease (8). Studies have been conducted to determine normative ambulatory blood pressure profiles (9-12). For example, a meta-analysis has been performed by Staessen et al. (13). In this meta-analysis of 22 published studies, ambulatory blood profiles were analyzed in 2,638 subjects who were considered to be normotensive by clinical criteria. The 24-h ambulatory blood pressure averaged 117/72 ( $\pm 2$  SD) mm Hg (range 97 to 137/57 to 87), daytime pressure 122/77 mm Hg (range 101 to 143/62 to 91) and nighttime pressure 106/64 mm Hg (range 86 to 127/48 to 79). The night/day pressure ratio averaged 0.87 (range 0.79 to 0.92) for systolic and 0.83 (range 0.75 to 0.90) for diastolic pressure. There are ongoing community-based studies in Europe at the present time that also provide data with regard to normal values and diurnal patterns (14,15).

Cross-sectional data have clearly shown an improved correlation between ambulatory blood pressure measurements over office blood pressure values and the presence of target organ complications of hypertensive disease (hypertensive changes in the heart, kidney, blood vessels and brain). Relations between the cardiac involvement have been studied most intensively and, in general, show stronger associations between ambulatory blood pressure (24-h) and left ventricular hypertrophy. Adding a measure of blood pressure load (percent of elevated systolic and diastolic pressures during a 24-h study) improves this correlation (8,16-19). The prognostic studies available, although limited, indicate that ambulatory blood pressure monitoring is superior to office blood pressure in predicting cardiovascular morbidity (20-22).

### Clinical Indications for Use

A Working Group for the National High Blood Pressure Education Program (NHBPEP) Coordinating Committee produced a consensus document on ambulatory blood pressure monitoring published in November 1990 (1). Similar recommendations resulted from other international consensus conferences on indirect ambulatory blood pressure mon-

itoring in 1990 and 1991 and from the German Hypertension League in 1991, and these have been included in the recommendations of the Fifth Report of the Joint National Committee on the Detection, Evaluation and Treatment of High Blood Pressure (JNC V, 1993) (23-26). The American College of Physicians also "support a more circumspect use of such devices for research and for the care of subgroups of hypertensive patients with specific clinical problems" (27,28).

### Cost Considerations

In considering overall cost-benefit relations for drug treatment of hypertension, economic models emphasize the greater cost in dollars for quality-adjusted life years for treatment of mild hypertension compared with that for treatment of moderate or severe hypertension (29,30). About 20% of patients considered to have mild hypertension by office values are normotensive on ambulatory blood pressure monitoring (31-34). Screening strategies that reduce the fraction of those initially identified as having mild hypertension and needing drug therapy can lead to substantial reduction in health care costs (35-38) and suggest that appropriately constrained ambulatory blood pressure monitoring can be highly cost-effective in this strategy. These models remain to be tested. There is a much smaller proportion of mild hypertensive patients whose blood pressure is higher outside the office (17,31). Better assessment of subjects with apparent resistance to therapy and erratic control leads to improved control of blood pressure and practice efficiencies (39).

### Recommendations

Ambulatory blood pressure monitoring has become a mature, clinically applicable technology, with available standards developed by the Association for the Advancement of Medical Instrumentation and the British Hypertension Society. American and international consensus meetings have developed clinical indications and guidelines for this procedure.

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