

Review Article

Noninvasive 24 hour ambulatory blood pressure monitoring: current status

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Introduction

Noninvasive intermittent blood pressure monitoring was first developed 30 years ago.¹ It is now evolving from its former role as a somewhat esoteric research tool to becoming a clinically useful procedure for the evaluation of hypertensive patients. In this review we outline its historical development, compare noninvasive 24-hour ambulatory blood pressure monitoring with the other available methods of blood pressure assessment, and evaluate the current roles for the technique in the diagnosis and management of hypertension.

Historical background

Arterial blood pressure may be measured directly by intra-arterial puncture, or indirectly by noninvasive means, by manual or automated techniques, and in stationary or ambulant subjects. The Reverend Steven Hales was the first to measure blood pressure directly in animals. He showed that blood rose to a height of over 8 feet in a glass tube placed in the artery of a horse.² A device suitable for measuring human intra-arterial pressure was developed by Jean-Leonard Marie Poiseuille in 1828,³ but it was not until 1969 that the first report of automated intra-arterial blood pressure recording in unrestricted ambulant man was published.⁴ The essential components for continuous intra-arterial pressure measurement using the popular 'Oxford System'⁵ are a fine intra-arterial catheter (in the brachial or radial artery) constantly perfused, a miniaturized pressure transducer and a magnetic tape recorder. This system can provide a complete accurate profile of blood pressure behaviour, measuring each individual beat over 24 hours, delineating beat-to-beat variability and circadian rhythms clearly in subjects performing

normal daily activities. Due to its invasive nature, the impact of direct inter-arterial blood pressure recording on clinical practice has been limited. Attention has thus turned to noninvasive or indirect techniques to obtain a profile of 24-hour blood pressure.

The first instrument for measuring blood pressure indirectly was devised by Jules Herisson in 1833, and consisted of a mercury reservoir covered by a rubber membrane from which a graduated glass column arose. The mercury bulb was compressed against the radial artery until the oscillations in the mercury column ceased, at which point systolic pressure was estimated. Many steps, too numerous to describe, have punctuated the development of modern indirect devices.⁶ Currently used devices use arm arterial occlusion⁷ and detect blood pressure level by Korotkov sound auscultation,⁸ oscillometry⁹ or ultrasonography.¹⁰ These indirect techniques of blood pressure measurement may be utilized in three ways – for conventional measurement of blood pressure in the clinic or surgery setting; for self-measurement of blood pressure usually in the home environment, and for automated measurement of blood pressure over the 24-hour period – each providing somewhat different information.

Clinical blood pressure measurements by doctors and nurses have been used since the turn of the century, but self-measurement of blood pressure by the patient has only been extensively explored in the last decade.^{11–14}

In 1962 Hinman and his colleagues described the first truly portable system for the intermittent noninvasive measurement of blood pressure in subjects performing their usual daily routine.¹ This system was developed commercially by the Remler company in California¹⁵ and consisted of a battery-operated recorder worn by the patient, a cuff which was inflated by the patient at predetermined intervals and a microphone strapped over the brachial artery. Blood pressures were recorded on a magnetic tape, which could be later decoded, and the pressure plotted over the period of recording.

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Because the device depended on inflation by the subject, recordings were confined to waking hours and rarely spanned more than 12–14 hours. With the development of compact pumps and solid-state memory systems, the Remler system has been replaced by devices capable of automatically inflating the cuff and providing pressure profiles over 24 hours such as those illustrated in Figures 1–6. The early models were noisy and bulky, but latterly they have become smaller, quieter and more 'patient friendly'. Also the number of such devices has increased. There are now at least 15 systems currently available¹⁶ and many more in the developmental stages.

Noninvasive blood pressure monitoring systems suffer from the disadvantage that during measurement the subject must discontinue all activity and provide support for the arm, and hence the measurements are static rather than truly 'ambulatory'. Additionally only an intermittent, as opposed to a continuous record of 24-hour blood pressure behaviour is provided. Despite these limitations noninvasive monitoring systems yield mean 24-hour values and diurnal/nocturnal patterns which are surprisingly close to those measured by continuous intra-arterial monitoring.¹⁷

Some attempts have been made to develop systems that provide indirect continuous 24-hour

blood pressure monitoring during rest and activity^{18,19} – in short the equivalent of direct intra-arterial measurement without the inherent dangers of arterial catheterization – but no such system has as yet proved sufficiently accurate. Hence the remainder of this review will focus on the status of noninvasive intermittent 24-hour 'ambulatory' blood pressure monitoring.

Device validation

The instruments for noninvasive pressure monitoring are expensive, both in terms of capital and running costs. As a result, it has become increasingly important that devices are shown to be accurate. In order to minimize reliance on manufacturers' reports, two groups have published validation protocols, the Association for the Advancement of Medical Instrumentation²⁰ and the British Hypertension Society.²¹ The Association for the Advancement of Medical Instrumentation (AAMI) criteria stipulate that the test device should not differ from the mercury measurement by more than 5 mmHg, with a standard deviation of less than 8 mmHg. The British Hypertension Society (BHS) protocol grades each device according to the percentage of measurements differing from the mercury standard by 5, 10 or 15 mmHg or

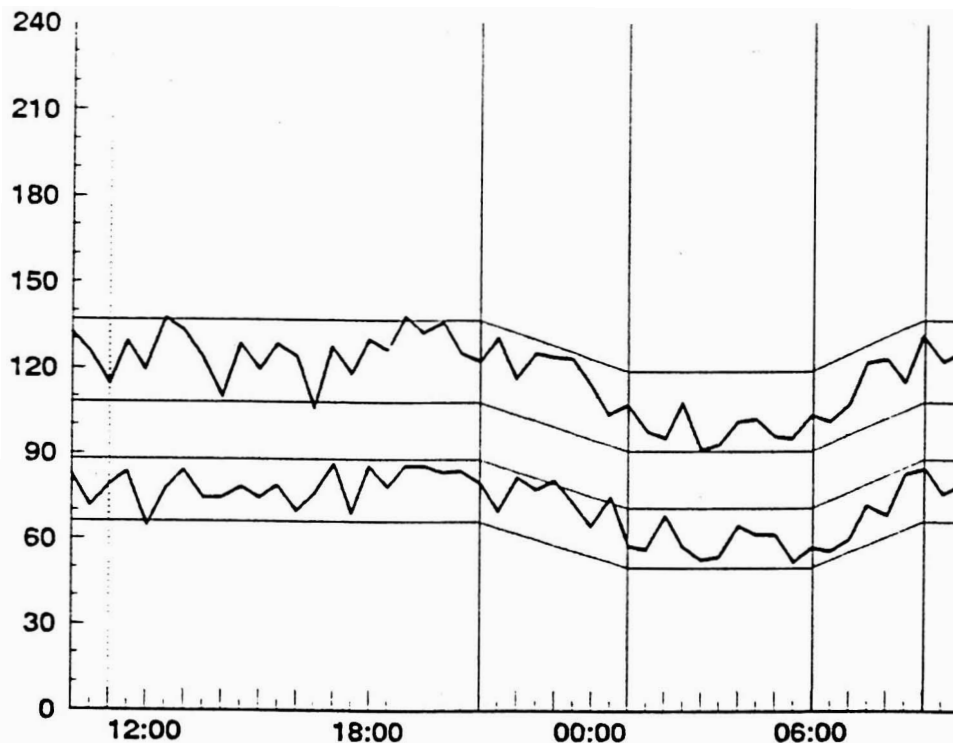


Figure 1 Twenty-four-hour ambulatory blood pressure profile from a normotensive subject with a normal circadian pattern. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

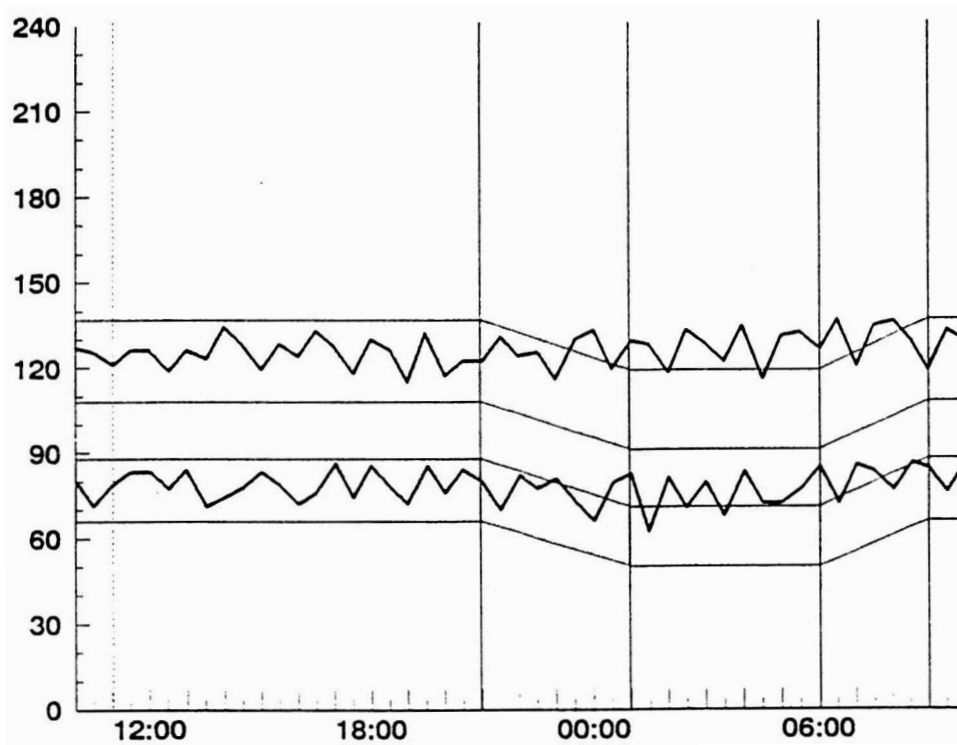


Figure 2 Twenty-four-hour ambulatory blood pressure profile from a subject with a blunted circadian pattern. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands, and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

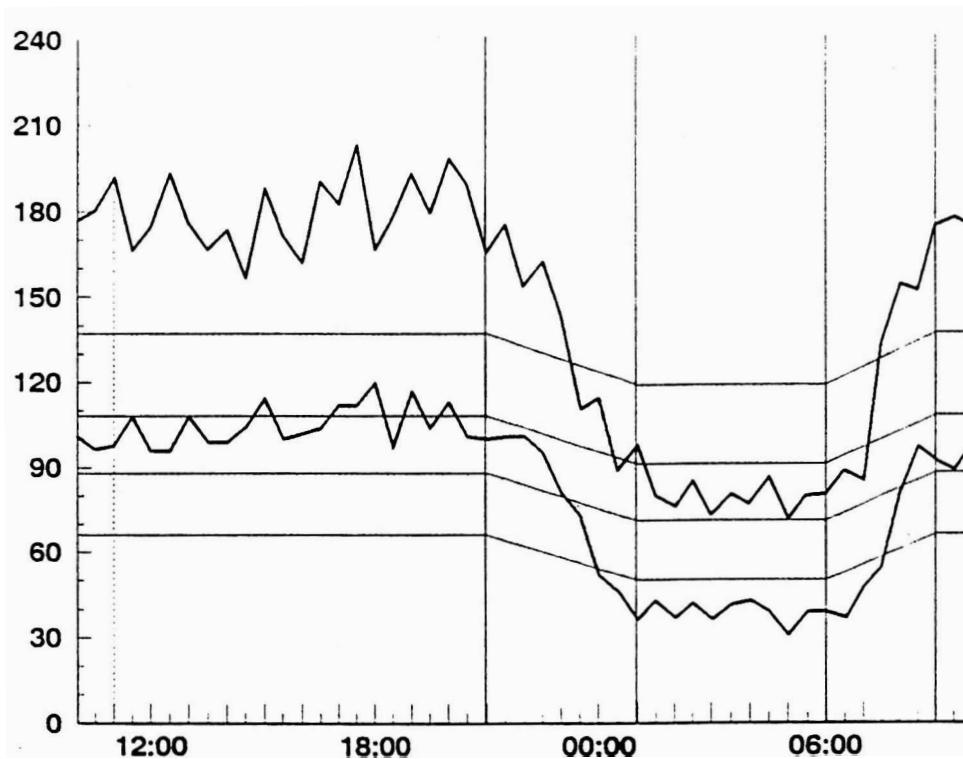


Figure 3 Twenty-four-hour ambulatory blood pressure profile from a subject with an accentuated circadian pattern. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands, and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

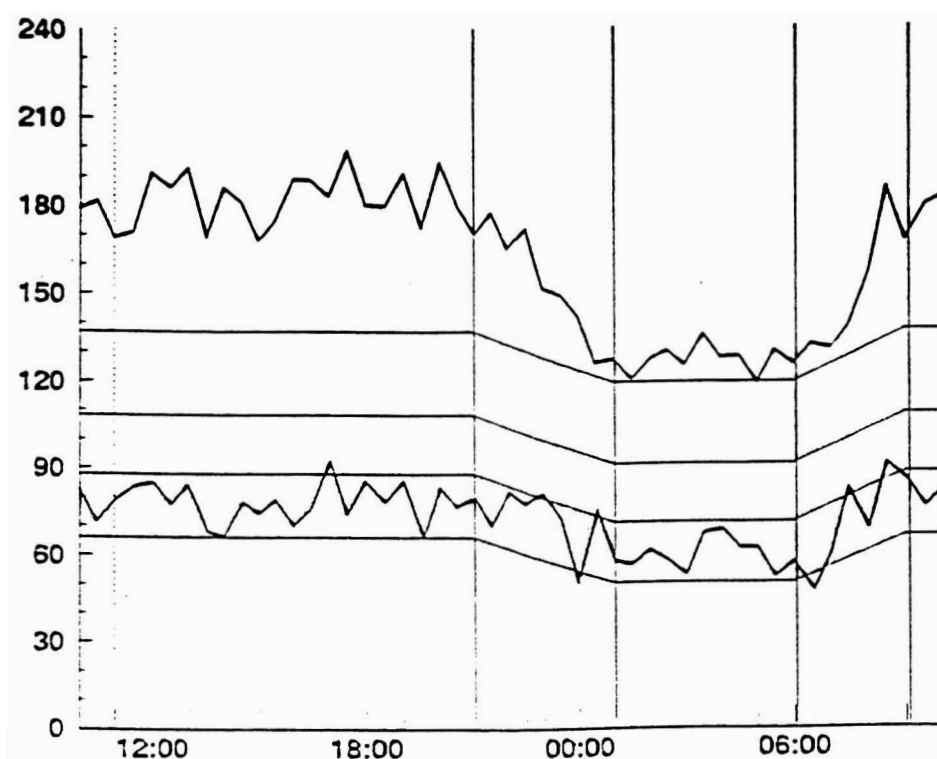


Figure 4 Twenty-four-hour ambulatory blood pressure profile from a subject with marked systolic hypertension but normal diastolic blood pressure. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands, and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

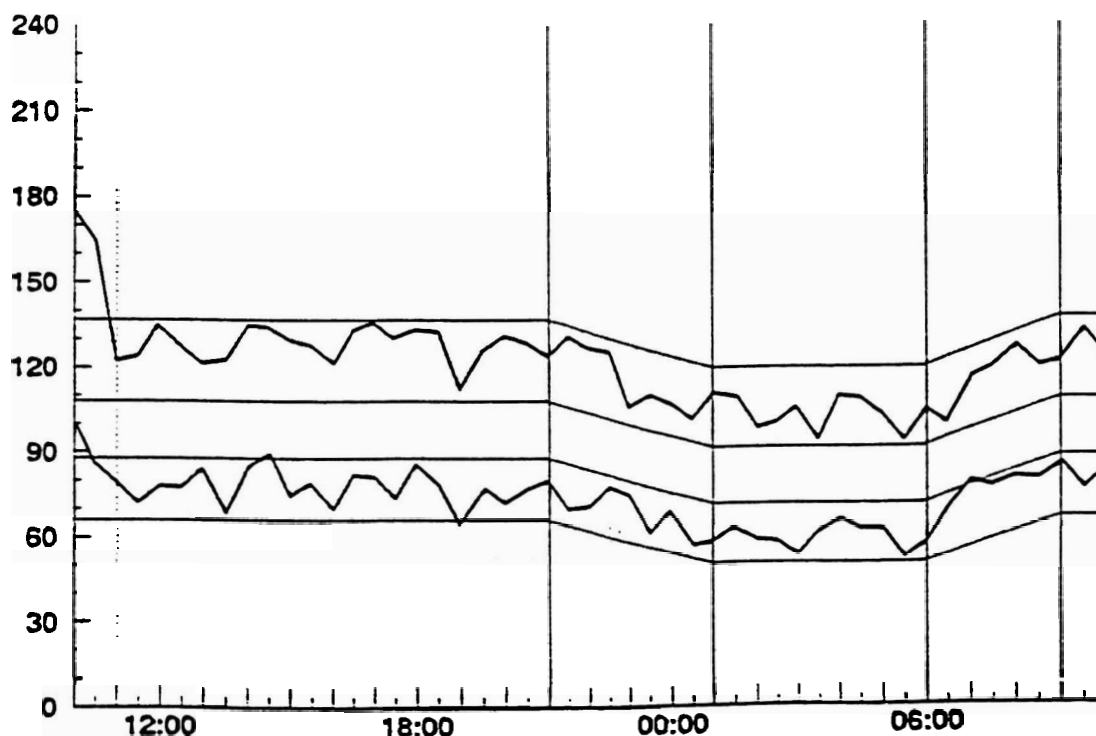


Figure 5 Twenty-four-hour ambulatory blood pressure profile from a subject with white-coat hypertension – only the initial blood pressure readings lie outside normotensive range. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands, and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

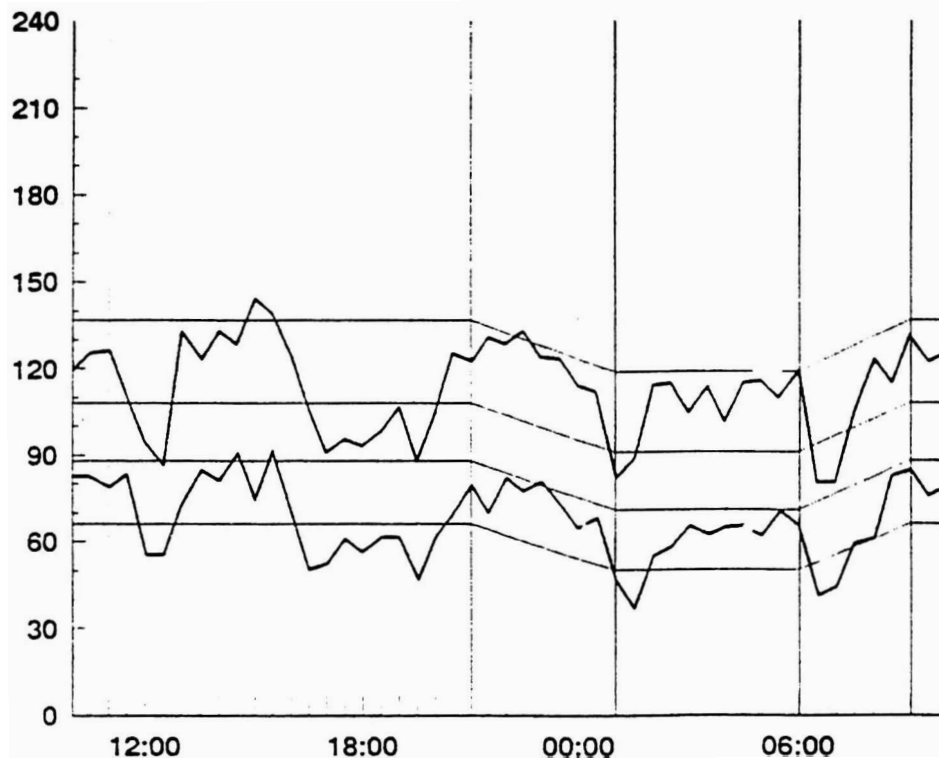


Figure 6 Twenty-four-hour ambulatory blood pressure profile from a subject with marked measurement-to-measurement variability. Time (hours) is plotted from the horizontal axis and blood pressure (mmHg), both systolic and diastolic, from the vertical axis. Normal values⁹⁷ are indicated by the shaded bands, and the vertical lines delineate initial, daytime, evening, night-time and early morning periods.

less. Prior to the main validation test the BHS protocol demands a high level of agreement between observers, assesses interdevice variability and, in addition, stipulates that the device be in use for a period of 1 month so as to ensure that device accuracy is not altered by the wear and tear of daily use. These protocols standardize independent assessments of automated devices and allow comparison of one system with another. The grading system of the BHS protocol provides a more sensitive estimate of accuracy than the AAMI standard which only allows for a pass or fail. O'Brien and colleagues comprehensively reviewed previous validation studies in 1990¹⁶ and have recently performed a number of comparative assessments, the results of which are summarized in Table I. Their data would suggest that, by both AAMI and BHS criteria, the CH-Druck device is the most accurate instrument, and that the Profilmat device and the SpaceLabs 90207 both perform satisfactorily. The other three devices, the Novacor DIASYS 200, the Pressurometer IV and the Takeda TM-2420 were less accurate.

Analysis of 24-hour blood pressure data

Noninvasive ambulatory blood pressure monitoring yields intermittent blood pressure and heart

rate data, in contrast to the single values of clinical readings and the continuous data of intra-arterial pressure monitoring. Many different methods have been proposed to analyse the large amount of data provided by 24-hour measurement.²²⁻²³ These can be classified into: (1) indices of average blood pressure such as the mean, median, or mode; (2) measure of dispersion or variability such as the range, fractiles, variance, standard deviation or the root mean squared successive differences; (3) methods of pattern analysis which include mean day-to-night differences, curve smoothing procedures or cumulative sums techniques; and (4) miscellaneous methods such as displaying the data as a frequency histogram or calculation of the load.

Measures of average blood pressure

The circadian pattern present in most 24-hour blood pressure profiles (Figures 1, 3-5)²⁴⁻²⁷ results in bimodal distributions on frequency histograms of blood pressure values taken over 24 hours.²⁸ Thus neither parametric nor non-parametric measures of centrality, the mean and the median, appear to adequately describe average 24-hour blood pressure behaviour. The two modes of the frequency histogram can be stated, or alternatively two new models may be utilized. An updated cumulative sums technique²⁹ allows identification

Table 1 Accuracy of ambulatory blood pressure monitoring devices determined by the British Hypertension Society protocol and the Association for the Advancement of Medical Instrumentation criteria

Device	BHS grade ^a		AAMI ^b	
	SBP	DBP	SBP	DBP
Takeda TM-2420	D	D	-4 ± 11	-2 ± 11
Pressurometer IV	C	D	-2 ± 11	-3 ± 11
Novacor DIASYS 200R	C	C	-1 ± 8	0 ± 8
SpaceLabs 90207	B	B	-1 ± 7	-3 ± 6
Profilomat	B	A	-3 ± 5	-1 ± 5
CH-Druck	A	A	-3 ± 4	-2 ± 4

^aThe BHS protocol grades each device according to the percentage of measurements differing from the mercury standard by 5, 10 or 15 mmHg or less (A = 80% ≤ 5 mmHg, 90% ≤ 10 mmHg, and 95% ≤ 15 mmHg; B = 65% ≤ 5 mmHg, 85% ≤ 10 mmHg, and 95% ≤ 15 mmHg; C = 45% ≤ 5 mmHg, 75% ≤ 10 mmHg, and 90% ≤ 15 mmHg and D = worse than C); ^bThe AAMI criteria stipulates that the test device should not differ by more than 5 mmHg from the mercury measurement, with a standard deviation of less than 8 mmHg (unpublished data from O'Brien and colleagues); SBP = systolic blood pressure; DBP = diastolic blood pressure.

of crest and trough blood pressures, the 6-hour periods of highest and lowest average pressures, respectively, while the square wave fit method³⁰ describes the 24-hour blood pressure profile as a square wave with a single period of high pressure and a single period of low pressure.

Measures of dispersion

Both short-term pressure variability and circadian patterns, in addition to average blood pressure levels, may influence independently morbidity and mortality in hypertension. Conventional measures of variability, the standard deviation and the interquartile range are influenced substantially by both circadian trends and by shorter term variability. By contrast the root of the mean squared successive differences is an almost pure measure of short-term blood pressure variability.³¹ It is very resistant to slow rhythms and linear trends. It provides a very sensitive index of measurement-to-measurement variability, from intermittent blood pressure data.

Pattern analysis

Discussions still abound as to the optimal quantification of circadian trends in 24-hour blood pressure data.³² The difference between mean daytime and night-time pressures is a commonly used measure, but circadian variation is not well modelled by clock time and interpatient variation in the timing of periods of activity and sleep introduces errors. Analyses of the circadian pattern according to the oscillator model, such as the

cosinor method,^{33,34} Fourier analysis,³⁵ or periodic spline functions,³⁶ assume incorrectly an endogenous rhythm.³⁷ These methods are exceedingly complex and in reality are nothing more than a statistical techniques describing the level of blood pressure as a function of time throughout the day. Cumulative sums techniques,³⁸ and square wave fitting,³⁰ neither of which are constrained by clock time, may be utilized to calculate circadian change as the difference between high and low pressure periods.

Coats and colleagues summarized the situation well,³⁹ 'Many statistical techniques can be used to describe different aspects of ambulatory records, but it is highly unlikely that any single parameter will suffice. A more realistic aim is for a combination of measures that combine statistical validity with physiological meaning and clinical usefulness. This will require compromises between conflicting demands, and only experience and research will ultimately determine the best summary statistics.'

Clinic blood pressures, ambulatory blood pressure values and prognosis

Clinic blood pressure measurements have long been the mainstay of hypertension diagnosis and management, owing to the weight of epidemiological evidence linking elevated clinic blood pressure readings with cardiovascular morbidity and mortality.³⁹⁻⁴¹ However, although the level of arterial pressure as measured at the clinic is an important risk factor in populations, its predictive value in individual patients is poor.³⁹⁻⁴¹ This poor

predictive power of clinic pressure readings may be due to the multifactorial nature of the pathogenesis of cardiovascular damage. Alternatively or additionally, any lack of accuracy of clinic pressure measurements in reflecting an individual's true average blood pressure would greatly weaken any association between blood pressure level and risk. Clinic pressure readings may not precisely reflect true average pressures for two principal reasons: firstly, the marked moment-to-moment variability of blood pressure;⁴²⁻⁴⁴ and secondly a phenomena known as the white coat effect, whereby a subject responds to the circumstance of blood pressure measurement.⁴⁵⁻⁴⁷

The white coat phenomenon has been most forcefully demonstrated in two studies by Mancia and colleagues.^{45,46} They showed that when a physician prepared to take a blood pressure reading with a mercury sphygmomanometer on one arm of the patient, there was a marked rise in intra-arterial pressure in the other arm, which persisted throughout the measurement procedure. The average rise in pressure evoked by the presence of a physician was 23/18 mmHg. White coat hypertension has been found to be present in as many as 25% of patients who carry a 'diagnosis' of hypertension.^{47,48}

Only the first few readings of 24-hour ambulatory blood pressure monitoring appear subject to this alerting response (Figure 5) and averaging of multiple blood pressure readings both reduces the influence of these first few readings and reduces variability, thereby improving the estimate of true average blood pressure.^{49,50} Hence, it would not be surprising if ambulatory blood pressure readings, averaged over 24-hours, over awake or over sleep periods, were better predictors of cardiovascular risk than clinical readings. This important question has only been addressed by the study of Perloff and colleagues,⁵¹ who showed that patients with elevated clinic blood pressure readings but normal daytime values had a similar prognosis to subjects with normal clinical and normal daytime readings, while those with elevated clinical and elevated daytime ambulatory values were at greater risk of cardiovascular events and death. Two important multicentre European studies are currently underway, the 'Office versus Ambulatory Trial' (OvA)⁵² and the 'Systolic Hypertension in the Elderly Study' (SYST-EUR),^{52,53} and both include in their aims the assessment of the correlation between treated 24-hour blood pressure and long-term prognosis.

In support of Perloff's unique study there are now many studies showing stronger correlations between hypertensive target organ damage and ambulatory pressures than between organ damage and clinic readings.⁵⁴⁻⁶³ As it is already well established that target organ damage in hypertension

predicts cardiovascular risk,⁶⁴⁻⁶⁹ the likelihood is that the study of Perloff *et al.*, showing ambulatory blood pressure to be a better predictor for stroke, heart attack and death than clinical measurement, will soon be confirmed (Figure 7).

It has been suggested that various patterns of blood pressure behaviour (Figures 1-6) might independently influence cardiovascular risk. Parati and colleagues⁷⁰ have provided convincing evidence, from inter-arterial pressure studies, that short-term blood pressure variability is positively correlated with end organ damage independently of the average 24-hour pressure level - those individuals with an ambulatory blood pressure profile such as that in Figure 6 would be at greater risk of organ damage and cardiovascular complications than those with a profile as in Figure 1.

Blood pressure usually follows a circadian rhythm (Figures 1, 3-5),²⁴⁻²⁷ with pressure levels higher during the day and lower at night. The usual nocturnal fall in blood pressure is diminished or absent in some subjects, and this has led to adoption of the terms 'dippers' (for the normal pattern) and 'non-dippers'. A blunted circadian pattern (Figure 2) has been reported to be associated with increased prevalence of left ventricular hypertrophy,⁷¹⁻⁷⁴ atherosclerosis⁷¹ and stroke.^{75,76} but matters are confounded by the possibility that those with accentuated circadian blood pressure changes (Figure 4) might also be at increased risk. Blood pressure peaks may influence the development of hypertensive target organ damage,^{77,78} and may also trigger such events as the rupture of an

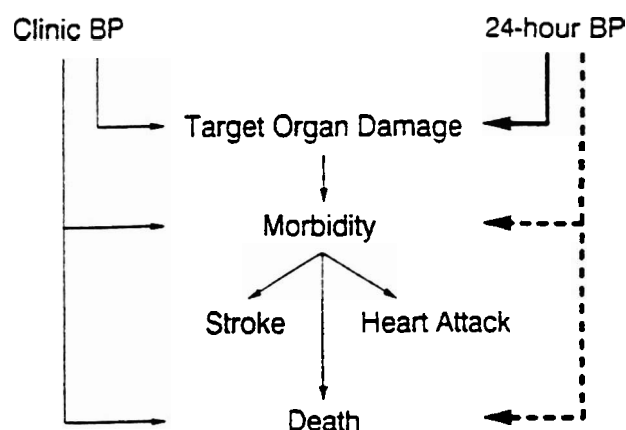


Figure 7 Scheme of reasoning the relationship of clinical blood pressure and ambulatory blood pressure to target organ damage, morbidity and mortality. The left-hand arrows indicate the established relationship between clinical blood pressure and target organ damage, and morbidity and mortality; the right-hand arrows indicate the established relationship of 24-hour ambulatory blood pressure with target organ damage and the likely, but as yet fully proven, relationship with morbidity and mortality.

atheromatous plaque.⁷⁹⁻⁸⁴ An excessive nocturnal reduction in blood pressure may critically reduce perfusion of vital organs, predisposing to cardiac,⁸⁵⁻⁹¹ limb⁹² and cerebral ischaemia.^{93,94}

Hence, while it is very probable that mean 24-hour ambulatory blood pressure levels will prove to be a better predictor of cardiovascular risk than clinical readings, the issue of the influence of spontaneous variability, circadian patterns, and night-time versus daytime blood pressure readings on morbidity and mortality is far from clear.

Twenty-four-hour blood pressure monitoring in clinical practice

Ambulatory blood pressure measurement is currently evolving from being purely a research tool into clinical practice. In order to avoid misuse, it is essential that all operators have an understanding of the normal ranges of ambulatory blood pressure readings,⁹⁵⁻⁹⁸ as well as the typical moment-to-moment blood pressure variabilities^{42-44,99} and usual circadian rhythms.²⁴⁻²⁷ In addition, the operator must be familiar with the equipment and with the calibration procedures. He/she must be prepared to give the necessary time to instruct the subject so that as many measurements as possible are obtained during the recording period. Subjects for ambulatory blood pressure measurement must be capable of coping with and caring for the recorder. The conditions of measurement for the subject should be standardized as far as possible in relation to activity: in particular the arm should be held still during each measurement;¹⁰⁰ a similar level of activity should be undertaken for comparative repeat measurements; working days should not be compared with recreational days and likewise in shift workers, comparative measurements should be made between similar shifts.^{32,33} The subjects should be asked to keep a diary of activities during the recording period, unless motion-logging, as an objective assessment of activity, is available.¹⁰¹

The clinical indications for using 24-hour noninvasive blood pressure measurement are best considered in relation to the diagnosis of hypertension or hypotension, and the selection and evaluation of anti-hypertensive drug treatment.

Diagnosis of hypertension

Normal values over 24 hours for adults according to gender and age have now been defined.⁹⁵⁻⁹⁸ Values for women during pregnancy are soon to be published.¹⁰² Hence by comparison with this normative data, monitoring is particularly helpful in deciding whether subjects with a borderline elevation in clinical blood pressure should be labelled

normotensive or hypertensive.¹⁰³ These subjects are currently likely to receive possibly unnecessary treatment on the basis of clinical readings, and may be penalized for insurance cover and employment.⁴⁸ As mentioned above ambulatory monitoring is an effective non-invasive method of determining whether blood pressure elevation is due solely to a white-coat effect.⁴⁷ If it is accepted that white-coat hypertensives do not need treatment, at least in the early stages, there is a prospect that 24-hour monitoring of blood pressure could be very cost-effective – the additional costs of the assessment would be more than offset by reductions in the numbers of patients perceived as needing anti-hypertensive drug treatment.¹⁰⁴ Elderly subjects with isolated systolic hypertension diagnosed by conventional methods are frequently found to have much reduced or essentially normotensive systolic pressures by ambulatory blood pressure monitoring.¹⁰⁵ The Syst-Eur study⁵³ results, when available, should clarify if these patients with elevated clinical systolic readings but normal ambulatory systolic values are at increased cardiovascular risk, and whether they should receive any anti-hypertensive medication. Patients with secondary hypertension frequently exhibit a non-dipping ambulatory blood pressure profile as in Figure 2 but as many patients with essential hypertension also have blunted circadian rhythms, ambulatory monitoring can not be used as a specific screening test for secondary hypertension.^{106,107}

Although not proven as yet, hypertensive patients with both attenuated and excessive circadian swings in blood pressure may be at increased risk of cardiovascular complications.^{72-94,108} The only way of determining dipper status is by performing 24-hour blood pressure monitoring.¹⁰⁸

Diagnosis of hypotension

Orthostatic hypotension, characterized by standing hypotension in conjunction with supine normotension or even hypertension, is not always easily detected in the clinical or office setting, and ambulatory blood pressure monitoring may play a valuable role in the diagnosis and assessment of therapeutic effects in patients with this condition.¹⁰⁹

Selection and evaluation of anti-hypertensive drug treatment

Ambulatory blood pressure monitoring provides an assessment of anti-hypertensive drug effect over 24 hours.¹¹⁰ There is some evidence that different groups of drugs may have different effects on the 24-hour blood pressure profile.¹¹¹ Beta adrenergic blocking agents may blunt the circadian pattern and angiotensin converting enzyme inhibitors may

accentuate the nocturnal dip in blood pressure.¹¹² and thus these two drug groups may be most suited to treating patients with marked daytime hypertension and those with a sustained elevation of pressure over the entire 24 hours, respectively. Evaluation of the 24-hour profile is particularly helpful in the assessment of drug efficacy in individuals in whom clinical readings consistently suggest poor control, despite intensive drug therapy (resistant hypertensives), and in patients with hypotensive symptoms, so as to guard against excessive therapy.^{103,113} Many patients whose hypertension was initially diagnosed by office measurement and whose blood pressure has been well controlled may well merit a drug-free period which can be assessed with safety by periodic 24-hour pressure monitoring.

A major issue to be resolved prior to 24-hour blood pressure monitoring realizing its full clinical potential in the evaluation of patients, is the recognition of the procedure by reimbursing agencies. While most experts in the field believe that 24-hour monitoring does have an important clinical role, there is also concern that the technique might be used excessively, particularly if the physician has a direct financial incentive to perform the test. As the number of patients with questionable blood pressure elevations is so enormous, and with ever-increasing interest and pressure from public and private health-care providers and from the pharmaceutical industry, it is important to lay down guidelines for the application of ambulatory blood pressure monitoring in clinical practice.^{103,114,115}

Twenty-four-hour blood pressure monitoring and clinical drug trials

Ambulatory blood pressure monitoring can improve and simplify clinical trials of anti-hypertensive drugs in a number of ways. Firstly, ambulatory monitoring allows identification and exclusion of those patients in whom the blood pressure is raised only in the clinic environment.⁴⁵⁻⁴⁸ These so-called 'white-coat hypertensives' do not have sustained hypertension and appear to respond differently to anti-hypertensive drugs and develop more side effects.¹¹⁶

Secondly, an important difference between conventional and ambulatory blood pressure measurement is the absence of a placebo response with the latter.^{117,118} The placebo response, whereby the administration of placebo is associated with a reduction in blood pressure, may be an artifact of clinical blood pressure measurement due to the inherent variability of arterial pressure resulting in regression to the mean or may be due to increasing familiarity of the patient with the clinical environ-

ment. In uncontrolled drug studies where clinical blood pressures are used as the measure of response, the reduction in blood pressure due to a placebo response may be attributed erroneously to the drug. The absence of placebo response with noninvasive ambulatory measurement should facilitate simplification of the design of efficacy studies of anti-hypertensive drugs, in that long placebo phases may be omitted.

Thirdly, averaging the multiple blood pressure readings so as to obtain a mean 24-hour ambulatory blood pressure value reduces variability as compared to single clinic readings, thereby improving the repeatability of blood pressure estimations.⁴⁹ In a study by Conway and Coats on 75 subjects the standard deviation of the difference in diastolic pressure between two clinic readings taken a month apart was 12.3 mmHg.⁵⁰ On 24-hour monitoring this difference fell to 6.3 mmHg. Since the number of subjects needed in a trial is related to the square of the standard deviation of the difference, the improved repeatability leads to a substantial reduction in the number of subjects needed.

Lastly, and perhaps most importantly, ambulatory blood pressure monitoring can provide a comprehensive assessment of the pattern of anti-hypertensive drug effect over time,^{119,120} clarifying their effects on circadian pattern,¹¹¹ and revealing any excessive lowering of blood pressure.¹¹³

In view of these many advantages of ambulatory blood pressure monitoring over clinical readings in the arena of clinical drug trials, it is somewhat surprising that the governmental regulating agencies in the United States and Europe have not approved, nor published guidelines for the use of ambulatory blood pressure monitoring in the evaluation of anti-hypertensive treatment, and have continued to seek casual blood pressure data alone. While the United States Food and Drugs Administration does not appear likely to approve ambulatory monitoring in the near future, as it finds that 'No drug development data have been submitted where ambulatory blood pressure data have been found useful in decision-making',¹²¹ proposals for European Commission guidelines that might make ambulatory pressure data a mandatory component of new drug applications, are being considered.¹²²

Conclusions

Noninvasive blood pressure monitoring has so many advantages over other available methods of blood pressure evaluation in the clinical diagnosis and management of individual hypertensive patients, and in the evaluation of anti-hypertensive drug efficacy that the technique is now becoming

established in clinical practice. The most important question now awaiting an answer is which of the many aspects of blood pressure behaviour that are

now quantifiable by noninvasive 24-hour ambulatory monitoring, will prove best in predicting long-term morbidity and mortality.

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