



ABC of hypertension: Blood pressure measurement

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*ABC of hypertension***Blood pressure measurement***Part III—Automated sphygmomanometry: ambulatory blood pressure measurement*

Eoin O'Brien, Gareth Beevers, Gregory Y H Lip

In recent years, the accuracy of the conventional Riva-Rocci/Korotkoff technique of blood pressure measurement has been questioned and efforts have been made to improve the technique with automated devices. In the same period, recognition of the phenomenon of white coat hypertension, whereby some subjects with apparent elevation of blood pressure have normal, or reduced, blood pressures when measurement is repeated away from the medical environment, has focused attention on methods of measurement that provide profiles of blood pressure behaviour rather than relying on isolated measurements under circumstances that may in themselves influence the level of blood pressure recorded.

These methodologies have included repeated measurements of blood pressure using the traditional technique, self measurement of blood pressure in the home or workplace, and ambulatory blood pressure measurement (ABPM) using innovative automated devices.¹

Setting up an ambulatory blood pressure measurement service**Which monitor to buy?**

A large variety of ambulatory blood pressure measurement devices are now available on the market, and the number will increase as the technique of ambulatory blood pressure measurement becomes more widespread. A number of factors should influence this choice, among which the most important is to ensure that the device has been validated independently according to either the protocol of the British Hypertension Society (BHS),² and/or that of the Association for the Advancement of Medical Instrumentation (AAMI).³

What type of service?

Doctors in practice may establish their own ambulatory blood pressure measurement service, refer patients to a hospital ambulatory blood pressure measurement service, or refer patients to a blood pressure clinic for full evaluation, which includes ambulatory blood pressure measurement. Often an open access referral service is used, with referral of problem or complicated cases for fuller evaluation in a blood pressure clinic.

Training requirements

The technique of ambulatory blood pressure measurement is specialised, and should be approached with care. An understanding of the principles of traditional blood pressure measurement, cuff fitting, monitor function and analysis and interpretation of ambulatory blood pressure measurement data as presented in the BHS Working Party CD Rom on blood pressure measurement is recommended.⁴ A nurse with an interest and experience in hypertension can master the use of ambulatory blood pressure measurement devices after relatively brief training. However, the analysis and interpretation of ambulatory blood pressure measurement profiles requires experience in the technique, which is best acquired by the doctor in charge of an ambulatory blood pressure measurement service.

This article has been adapted from the newly published 4th edition of ABC of Hypertension. The book is available from the BMJ bookshop and at www.bmjbooks.com

Essential messages

- Consider carefully which monitor to buy
- Consider which type of service is best suited to your needs
- Consider analysis and presentation of data
- Exclusion of white coat hypertension is a major indication
- The technique is valuable in the elderly
- The technique is being increasingly used in pregnancy

Which monitor to choose

- Check for independent validation by BHS/AAMI protocols
- How much will it cost?
- How expensive is the software?
- Is the software what you need?
- Are the instructions adequate?
- How much will maintenance cost?
- How expensive are consumables—batteries, etc?
- Have you adequate computer facilities?
- Is the technical/nursing back up available?
- Are training facilities available?
- Is the warranty adequate?
- Is there an adequate servicing facility?



SpaceLabs 90207 ABPM monitor

Details of ABPM device manufacturers

Additional information about manufacturers can be found on the *BMJ*'s website: www.bmj.com. See also O'Brien et al. *BMJ* 2001;322:531-6

Using an ambulatory blood pressure measurement monitor

Time needs to be given to fitting the monitor and preparing the patient for the monitoring period if good results are to be obtained.¹ The key to successful ambulatory blood pressure measurement is educating the patient in the process of monitoring and instructions should be explained and printed on a diary card. In clinical practice measurements are usually made at half hourly intervals so as not to interfere with activity during the day and with sleep at night, but measurements can be made more frequently if indicated. There are a number of ways of analysing blood pressures recorded during the 24 hour cycle.⁵ One simple and popular method is to assess the time of awakening and sleeping from diary card entries. Another is to use a fixed time method in which the retiring (2101 to 0059) and rising (0601 to 0859) periods during which blood pressures are subject to considerable variation are eliminated, with the daytime period being from 0900 to 2100 and night time from 0100 to 0600; in this way the variations that may exist between the young and the old and in different cultures are to some extent eliminated from the analysis.

Presenting the data

Many statistical techniques exist for describing different aspects of ambulatory records, and no one method is ideal.¹ The important points are summarised in the box.

The detection of artefactual readings and the handling of outlying values (which may or may not be erroneous) have been the subject of debate, and if there are sufficient measurements editing is not necessary.

Ambulatory blood pressure measurement devices are usually sold with individual software packages, which present data in a variety of ways. It would facilitate practice if the graphic presentation of ambulatory blood pressure measurement data were standardised, much as is the case for ECG recordings. Such a standardised approach might provide a graphic display of ambulatory blood pressure measurement data (on screen or printout) with a visual time/pressure graph with blood pressure plotted on the vertical axis and time on the horizontal axis, and levels of normality can also be shown.^{6,7} One program (DABL®, Cardiovascular 2000 ECF Medical, Dublin, Republic of Ireland) provides a printed report derived from the ambulatory blood pressure measurement data.⁶

The issue of normality/abnormality in ambulatory blood pressure measurement is controversial, but the levels shown in the table below are commonly used.⁸ The evidence from ongoing longitudinal studies gives some support to lower levels of normality for ambulatory blood pressure measurement, and we appreciate that these levels may be regarded as conservative by some.

Recommended levels of normality for ambulatory blood pressure measurement

	Normal	Abnormal
Daytime	≤135/85	>140/90
Night time	≤120/70	>125/75
24 hour	≤130/80	>135/85

The evidence supporting these demarcation levels is based on firm evidence from a number of studies; the evidence is not yet available to make recommendations for the intermediate pressure ranges between the "normal" and "abnormal" levels, nor for recommendations lower than those given. It must be emphasised that these levels are only a guide to "normality" and that lower levels may be taken as "abnormal" in patients whose total risk factor profile is high, and in whom there is concomitant disease, such as diabetes mellitus.⁹

Using an ambulatory blood pressure monitor

- 15-30 minutes needed
- Relax patient in a quiet room
- Enter patient details into monitor
- Measure BP in both arms
 - If SBP difference < 10 mm Hg use non-dominant arm
 - If SBP difference ≥ 10 mm Hg use higher pressure arm
- Select appropriate cuff—see BHS recommendations
- Select frequency of measurement—usually every 30 minutes day and night
- Inactivate LCD display
- Give patient written instructions and a diary card
- Instruct patient how to remove and inactivate monitor after 24 hours

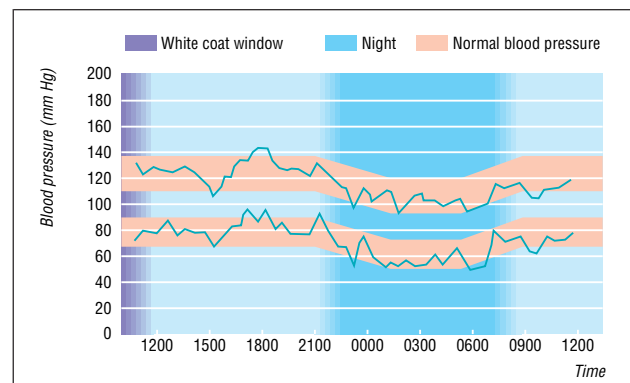
Instructions for patients

(To be explained to patient and reinforced on instruction/diary card)

- Explain procedure
- Explain frequency of inflation and deflation
- Explain how to deflate manually
- Explain about failed measurements and what the monitor will do
- Instruct to keep arm steady during measurement
- Instruct to keep arm at heart level during measurement
- Instruct to engage in normal activities between measurements
- Instruct to keep monitor attached at night
- Instruct to place monitor under pillow or on bed at night
- Provide a help line number for problems or anxiety
- Provide diary card for the following:
 - level of activity at time of blood pressure measurement
 - time of going to bed
 - time of rising
 - time of taking medication
 - record any symptoms

Presenting the data

- Number of measurements
 - Day > 14 SBP and DBP measurements
 - Night > 7 SBP and DBP measurements
- Causes of poor ABPM
 - Poor technique
 - Arrhythmias
 - Small pulse volume
 - Inability of automated devices to measure blood pressure
- Editing data
 - Restrict editing to physiologically impossible pressures, eg DBP = SBP
- Displaying data
 - Plot data (see figure)
 - Statistics to include:
 - Mean daytime SBP and DBP and heart rate
 - Mean night time SBP and DBP and heart rate
 - Mean 24 hour SBP and DBP and heart rate



Example of a normal ambulatory blood pressure pattern plotted by the DABL® Program.

Clinical indications for ambulatory blood pressure measurement

Ambulatory blood pressure measurement provides a large number of blood pressure measurements over a period of time—usually the 24 hour period—which can be plotted to give a profile of blood pressure behaviour. Although in practice the average day (or night time) blood pressures are used to govern decisions, the clinical use of ambulatory blood pressure measurement has allowed for a number of phenomena in hypertension to be more clearly identified than is possible with other methods of blood pressure measurement.⁷⁻¹⁰ Ambulatory blood pressure measurement can benefit patients with hypertension in the categories in the box opposite.

Patients with white coat hypertension

From the first use of home and ambulatory monitoring, it became apparent that the clinic or office blood pressure could be elevated over and above the ambulatory mean blood pressure, due to the white coat phenomenon, which may convert ambulant normotensives into clinic hypertensives. The features of white coat hypertension are summarised in the box. In normotensive people daytime ambulatory blood pressure may be a little higher than conventional blood pressure, but in hypertensive subjects daytime blood pressure is usually substantially, but unpredictably, lower than conventional blood pressure.

Patients with clinic borderline hypertension

The same reasoning applies to patients with borderline elevation of blood pressure, especially young subjects, in whom lifelong drug therapy may be inappropriately prescribed, and who may be penalised for insurance or employment if the diagnosis of “hypertension” is misapplied.

Elderly patients in whom treatment is being considered

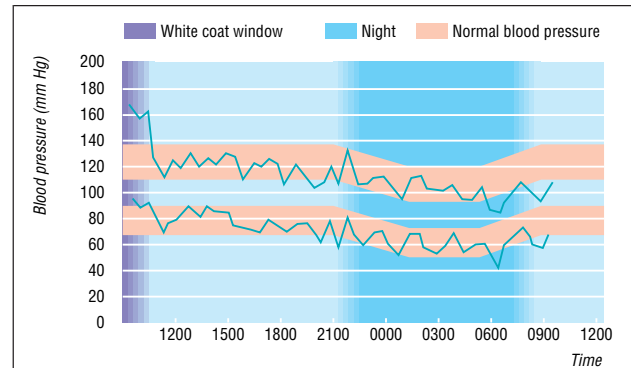
The results of the ambulatory study of the Systolic Hypertension in Europe (SYSTE-Eur) trial show that systolic blood pressure measured conventionally in the elderly may average 20 mm Hg higher than daytime ambulatory blood pressure,¹¹ thereby leading to inevitable overestimation of isolated systolic hypertension in the elderly and probable excessive treatment of the condition. Moreover, results from this study also show that ambulatory systolic blood pressure was a significant predictor of cardiovascular risk over and above conventional systolic blood pressure. A variety of ambulatory patterns are found in the elderly, among which are a number of hypotensive states due to baroreceptor or autonomic failure.¹² As the elderly can be very susceptible to the adverse effects of blood pressure lowering drugs, identification of hypotension becomes particularly important, though its management may present a considerable therapeutic challenge.

Nocturnal hypertension

Ambulatory blood pressure measurement is the only non-invasive blood pressure measuring technique that permits measurement of blood pressure during sleep. The relevance of nocturnal hypertension is still controversial, but there is increasing evidence that night time blood pressure may provide important information.¹³ Nocturnal blood pressure levels, for example, are independently associated with end organ damage,¹⁴ over and above the risk associated with daytime values. It has also been shown that absence of nocturnal “dipping” of blood pressure to lower levels than during the day is associated with target organ involvement, and may be a useful (though non-specific) clue as to the presence of secondary hypertension.

Possible clinical indications for ambulatory blood pressure measurement

- Exclusion of white coat hypertension
- Deciding diagnosis in borderline hypertension
- Elderly patients for treatment
- To identify nocturnal hypertension
- Hypertensive patients resistant to treatment
- As a guide to antihypertensive drug treatment
- Hypertension of pregnancy
- To diagnose hypotension



White coat hypertension

Features of white coat hypertension

- Definition
 - Abnormal office blood pressure $\geq 140/90$ mm Hg
 - Normal daytime ambulatory blood pressure $< 135/85$ mm Hg
- Prevalence of white coat hypertension
 - 15-30% general population
 - 30% pregnancy
- Risks from white coat hypertension
 - Considerably less than sustained hypertension
 - Probable small risk compared to normotensives
 - Possibly a prehypertensive state?
 - Not an entirely innocent condition
- Clinical implications
 - No clinical characteristics to assist diagnosis
 - Must be considered in newly diagnosed hypertensives
 - Should be considered before drug prescribing
 - Must be placed in context of overall risk profile
 - Reassurance for employment
 - Reassurance for insurance and pension liability
 - Common in the elderly and pregnancy
 - Less drug prescribing
 - Need for follow up and re-monitoring

Ambulatory blood pressure patterns in the elderly

- White coat hypertension
- Isolated systolic hypertension
- Postural hypotension
- Post-prandial hypotension
- Daytime hypotension/nocturnal hypertension
- Drug induced hypotension
- Autonomic failure

Patients with resistant hypertension

In patients whose conventional blood pressure remains consistently above 150/90 mm Hg in spite of treatment with three antihypertensive drugs, ambulatory blood pressure measurement may indicate that the apparent lack of response is due, in fact, to the white coat phenomenon, or the presence of a non-dipping nocturnal pattern may suggest secondary hypertension.

Ambulatory blood pressure measurement in pregnancy

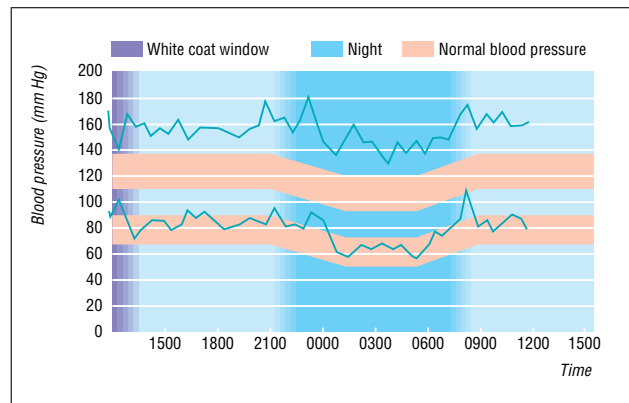
As in the non-pregnant state, the main use for ambulatory blood pressure measurement in pregnancy is the identification of white coat hypertension, which may occur in nearly 30% of pregnant women.¹⁵ Its recognition is important, so that pregnant women are not admitted to hospital or given antihypertensive drugs unnecessarily or excessively. Normal values for ambulatory blood pressure in the pregnant population are available, and the changes in pressure which occur during the trimesters of pregnancy and in the postpartum period have been defined.¹⁶ The evidence that ambulatory blood pressure measurement may predict pre-eclampsic toxemia is not yet conclusive. However, ambulatory blood pressure correlates better with proteinuria than does conventional sphygmomanometry, it is a better predictor of hypertensive complications, and women diagnosed by the technique as having hypertension have infants with lower birth weight than normotensive women.¹⁶⁻²⁰ Moreover, women with white coat hypertension tend to have more caesarean sections than normotensive women, suggesting that if ambulatory blood pressure measurement was used to measure blood pressure rather than the conventional technique, caesarean delivery might be avoided.¹⁵

Ambulatory hypotension

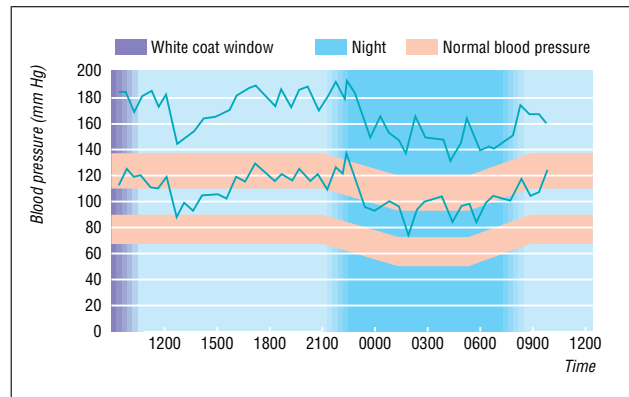
Reference has already been made to the clinical use of ambulatory blood pressure measurement in identifying hypotensive episodes in the elderly, but it may also be used in young patients in whom hypotension is suspected of causing symptoms. Ambulatory blood pressure measurement may also demonstrate drug induced drops in blood pressure in treated hypertensive patients, which may have untoward effects in patients with a compromised arterial circulation, such as those with coronary and cerebrovascular disease.²¹

Ambulatory blood pressure measurement in drug treatment

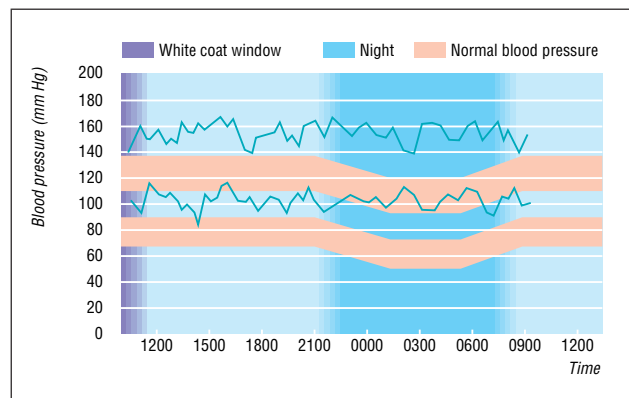
The role of ambulatory blood pressure measurement in guiding drug treatment is currently the subject of much research, and its role in this regard has not yet been fully established. However, recent reviews of the clinical value of ambulatory blood pressure measurement have highlighted the potential of 24 hour recordings of blood pressure in guiding antihypertensive medication. Furthermore, a recent well controlled study showed that when ambulatory blood pressure measurement was used as the basis for prescribing rather than clinic blood pressure, significantly less antihypertensive medication was prescribed.²² Quite apart from this attribute, ambulatory blood pressure measurement gives the prescribing doctor an assessment of the response to treatment that conventional measurement cannot provide: the efficacy of treatment without the white coat effect can be ascertained, excessive drug effect and the occurrence of symptoms can be determined, and the duration of drug effect over the 24 hour period can be demonstrated.



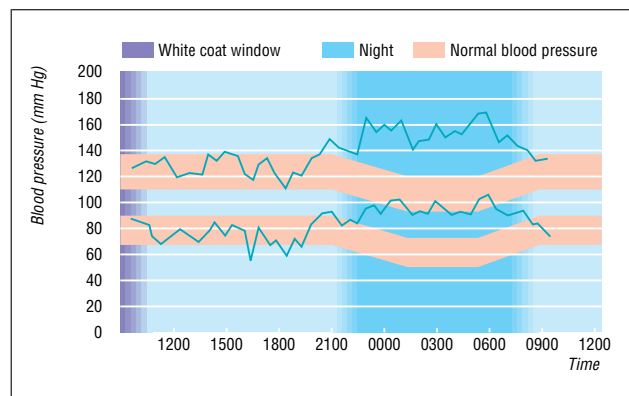
Isolated systolic hypertension



Systolic and diastolic hypertension with night time dip



Systolic and diastolic hypertension without night time dip



Nocturnal hypertension

Who should be re-monitored?

Ambulatory blood pressure measurement causes inconvenience to patients, and it should be used, therefore, with discretion. The decision as to when to repeat ambulatory blood pressure measurement is largely one of clinical judgment, which may be influenced by factors such as excessive blood pressure variability, an inappropriate response to treatment, an adverse risk factor profile, and the need for careful control of blood pressure, such as in hypertensive patients with diabetes mellitus or renal disease. As a general rule it is usually unnecessary to repeat ambulatory blood pressure measurement more frequently than annually.¹ Conventional blood pressure measurement may be relied on for follow up in patients who do not have a white coat effect on ambulatory blood pressure measurement. The patients in whom re-monitoring may be helpful are listed in the box.

Indications for re-monitoring

Usually annual re-monitoring is sufficient

- Patients with white coat hypertension
- Treated patients with white coat effect
- Elderly patients with hypotension
- Patients with nocturnal hypertension
- Changes in medication

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Lateral thinking

A 13 year old boy presented to my surgery with an eight hour history of left iliac fossa pain. It was worse on some movements, gripping in nature, and present most of the time. He denied any other symptoms, and there was no recent injury. He was generally well, although he was small and taking growth hormone for hypopituitarism.

My examination of the abdomen was unremarkable. Having loosened his tracksuit trousers, my drawing his pants down to examine his testicles evoked a dramatic giggly response followed by arching of his back and pallor. He denied any local testicular tenderness. He then pulled up his trousers and pants, and subsequent flexion of his left hip was normal, but right hip flexion resulted in pronounced left iliac fossa pain. His urine was clear.

Given his extreme reaction to his testicular examination, my initial thoughts focused on psychogenic pain. I raised the issue of bullying at school and asked the boy and his parents to come back the next day if the pain had not settled.

Between patients, I mulled over the case. Why would right hip flexion cause left iliac fossa pain? I climbed onto the couch and flexed my right hip. Suddenly it became obvious. I telephoned the parents and reviewed the boy immediately. Closer examination of the testes revealed a swollen left testicle, palpation of which

caused referred lower left abdominal pain—and the same reaction. The parents had private health insurance, and I found a paediatric surgeon about to finish his list who could see the boy. Not having eaten or drunk recently, he was operated on within the hour, the torsion was relieved and the testicle saved.

Is this a new sign—as the right hip is flexed, the crutch of the trousers tighten and squeeze mainly the left testicle? And what should it be called—the cross trouser squeeze sign, the contralateral hip flexion pain sign?

Derek Chase *general practitioner, Cavendish Health Centre, London*

We welcome articles of up to 600 words on topics such as *A memorable patient, A paper that changed my practice, My most unfortunate mistake*, or any other piece conveying instruction, pathos, or humour. If possible the article should be supplied on a disk. Permission is needed from the patient or a relative if an identifiable patient is referred to. We also welcome contributions for "Endpieces," consisting of quotations of up to 80 words (but most are considerably shorter) from any source, ancient or modern, which have appealed to the reader.