

4 Measurement of blood pressure

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Part I Aspects of measurement of blood pressure common to technique and patient

Technique

Selection of an accurate device

An accurate device is fundamental to all measurements of blood pressure. If the device is inaccurate, attention to the detail of measurement methods is of little relevance. The accuracy of devices for measurement of blood pressure should not be judged on the sole basis of claims from manufacturers, which can be extravagant. Instead devices should be validated according to international protocols in peer reviewed journals.

The website [dableducational](http://dableducational.org) provides updated assessments of all devices used to measure blood pressure and indicates which have passed or failed independent validation (see example table below—for full details go to www.dableducational.org)

Sphygmomanometers for self-measurement of blood pressure—devices for the upper arm

Device	Mode of measurement	AAMI	BSH	ESH	Circumstance	Recommendation
A&D UA-631 (UA-779 Life Source)	Oscillometric			Pass	At rest, recruitment violations	Recommended
A&D UA-704	Oscillometric		A/A		Study details omitted	Questionable
A&D UA-767	Oscillometric	Pass	A/A		At rest; not high blood pressure	Recommended
A&D UA-767 Plus	Oscillometric		A/A A/A A/A		At rest; tables incomplete At rest; recruitment violations At rest; recruitment violations; simultaneous readings	Recommended Questionable Questionable
A&D UA-787	Oscillometric			Pass		Recommended
Microlife BP 3AC1-1	Oscillometric			Pass		Recommended
Microlife BP 3BTO-A	Oscillometric		A/A		Small recruitment violation	Recommended
		Pass	A/B		Normotensive pregnancy	Recommended
		Pass	B/B		Non-proteinuric high blood pressure	
		Pass	A/B		Pre-eclampsia	
Omron HEM-705IT	Oscillometric			Pass		Recommended
Omron M5-I	Oscillometric			Pass		Recommended
Omron MX3 Plus	Oscillometric			Pass	Recruitment ranges omitted; from plot, high range of diastolic blood pressure seems undersubscribed	Questionable
Rossmax	Oscillometric on inflation			Fail	At rest	Not recommended
Visomat OZ2	Oscillometric	Pass	C/B		At rest	Not recommended
Welch-Allyn transtelephonic home monitor	Oscillometric	Pass			Parkinson's disease	Questionable

AAMI = American Association of Medical Instrumentation; BSH = British Hypertension Society; ESH = European Society for Hypertension.

Variability of blood pressure

No matter which measurement device is used, blood pressure is always a variable haemodynamic phenomenon. Modification of the factors that influence variability is not always possible, but we can minimise their effect. When optimum conditions are not possible, this should be noted with the reading.

White coat hypertension and the white coat effect

Anxiety increases blood pressure—often by as much as 30 mm Hg—when patients are frightened and extremely anxious, when it is often referred to as the white coat effect. This effect should be distinguished from white coat hypertension, in which a person with normal blood pressure has hypertension during measurement by doctors and nurses but blood pressure returns to normal away from the medical environment. White coat

Factors that influence blood pressure variability

- | | |
|--------------------------------|--|
| • Circumstances of measurement | • Temperature |
| • Respiration | • Bladder distension |
| • Emotion | • Pain |
| • Exercise | • Age |
| • Meals | • Race |
| • Tobacco | • Diurnal variation (blood pressure lowest during sleep) |
| • Alcohol | |

ABC of hypertension

hypertension is shown best by ambulatory blood pressure measurement (Part III).

These white coat phenomena are important because a decision to reduce blood pressure, and especially to administer drugs, never should be made on the basis of measurements taken in circumstances in which the white coat effect or white coat hypertension is likely to occur.

Optimum conditions for measurement

- Relaxed patient
- Comfortable temperature
- Quiet room—no telephones or noises

Posture

Posture affects blood pressure, with a general tendency for it to decrease when a person moves from the lying position to the sitting or standing positions. Some patients may have postural hypotension, especially those who are taking certain antihypertensive drugs and elderly people. When this is likely, blood pressure should also be measured when the patient is standing.

Arm support

If the arm in which blood pressure is being measured is unsupported—as tends to happen when the patient is sitting or standing—the patient is performing isometric exercise, which increases blood pressure by as much as 10%. The arm therefore must be supported during measurement of blood pressure, especially when the patient is in the standing position. This is achieved best in practice by the observer holding the patient's arm at the elbow.

Arm position

The forearm should be at the level of the heart—that is, the mid-sternum. Measurement in an arm lower than the level of the heart leads to an overestimation of systolic and diastolic pressures, while measurement in an arm above the level of the heart leads to underestimation. Such inaccuracy can be as much as 10 mm Hg, especially when the patient is in the sitting or standing position, when the arm is likely to be below heart level by the side. Arm position is important for self measurement of blood pressure with devices for wrist measurement. Many of these devices inherently are inaccurate, but measurement is even less accurate if the wrist is not held at the level of the heart during measurement.

Which arm?

Arterial disease can cause differences in blood pressure between arms, but because blood pressure varies from beat to beat, any differences may simply reflect blood pressure variability or measurement errors, or both. Bilateral measurement should be made at the first consultation; if differences >20 mm Hg for systolic or 10 mm Hg for diastolic blood pressure are present on consecutive readings, the patient should be referred to a cardiovascular centre for further evaluation with simultaneous bilateral measurement and the exclusion of arterial disease.

Cuff and bladder

The cuff is an inelastic cloth that encircles the arm and encloses an inflatable rubber bladder. The cuff is secured around the arm most often by means of Velcro on the adjoining surfaces of the cuff, occasionally by wrapping a tapering end into the encircling cuff, and rarely by hooks. Velcro surfaces must be effective; when they lose their grip, the

White coat phenomena

White coat effect

- Also known as: Fight and flight phenomenon, alarm reaction, defence reaction
- Occurs in medical environment—for example, emergency department or surgery
- Occurs in people with normal blood pressure and hypertension
- Decreases with familiarisation

White coat hypertension

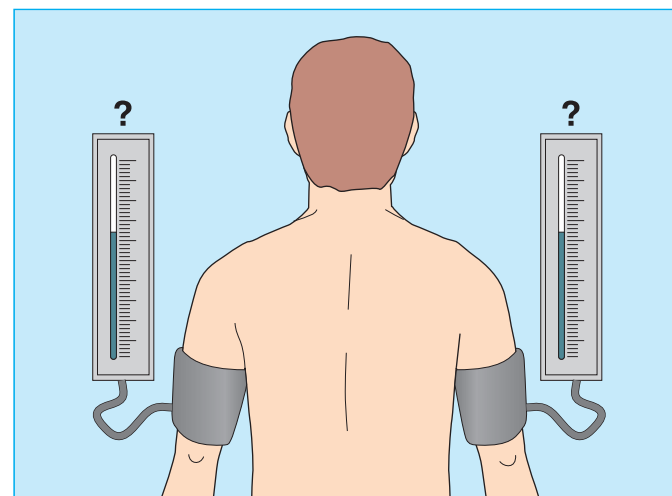
- Occurs in medical environment
- People with normal blood pressure become hypertensive. People with hypertension have higher blood pressures in a medical environment
- Tends to persist during repeated visits

Posture and position

- Measure blood pressure routinely with patient in sitting position
- Back should be supported
- Legs should be uncrossed
- Patient should be relaxed
- Measure after ten minutes of rest
- Measure after two minutes of standing if indicated



Arm support during blood pressure measurement



Which arm?

Measurement of blood pressure

cuff should be discarded. The bladder should be removable from the cuff for washing.

Cuff hypertension

However sophisticated a blood pressure measuring device, if it is dependent on cuff occlusion of the arm (as most devices are), it will be prone to the inaccuracy of miscuffing. This occurs when a cuff contains a bladder that is too long or too short relative to the circumference of the patient's arm. Miscuffing is a serious source of error that leads inevitably to incorrect diagnosis in clinical practice and erroneous conclusions in research into hypertension. A further problem is that inflation of the cuff itself may result in a transient but substantial increase (up to 40 mm Hg) in the patient's blood pressure.

Solutions

Correction factors on the cuff to avoid measurement errors from an inappropriate bladder complicate blood pressure measurement and are not used often. Cuffs that contain a variety of bladders of varying dimensions are available (such as Tricuff, Pressure Group AB, Sweden), but they are expensive and can be difficult to apply because of stiffness of the cuff. A "universal" cuff adjustable for all arm dimensions has been proposed but not manufactured successfully yet.

A cuff that contains a bladder that measures 35 × 12 cm was used for a time on the basis that it would encircle most adult arms, but it introduced errors by overcuffing lean arms. Many national bodies now recommend a range of cuffs to cater for all eventualities, which presupposes that the user will measure the arm circumference and, having done so, will have access to an adequate range of cuffs. In practice, neither of these requirements is easily fulfilled.

Unfortunately, societies differ in their recommendations. The striking difference between the American and British recommendations is not so much the length of the bladders but the width: most European arms will comfortably accommodate a bladder with a width of 12 cm, but a bladder with a width of 16 cm is likely to encroach on the antecubital fossa—particularly if (as often happens in practice) the sleeve of the patient's shirt or blouse is rolled up.

The subject

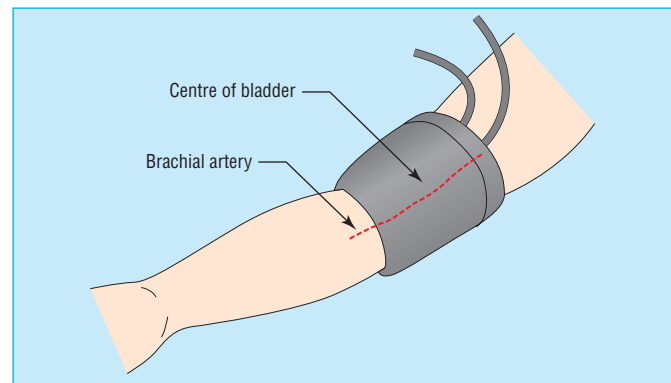
Special management of blood pressure

Certain groups of people merit special consideration for the measurement of blood pressure—because of age, body habitus, or disturbances of blood pressure related to haemodynamic alterations in the cardiovascular system.

Children

Measurement of blood pressure in children presents a number of difficulties. Variability of blood pressure is greater than in adults, and any one reading is less likely to represent the true blood pressure. Systolic pressure is more accurate and reproducible than diastolic pressure. A cuff with proper dimensions is essential for accurate measurement. The widest cuff practicable should be used.

Ideally, blood pressure should be measured after a few minutes of rest. Values obtained during sucking, crying, or eating will not be representative. As with adults, a child's blood pressure status should be decided only after it has been measured on a number of separate occasions.



Placement of cuff

Mismatching of bladder and arm

Bladder too small (undercuffing)	Bladder too large (overcuffing)
<ul style="list-style-type: none"> • Overestimation of blood pressure • Range of error: <ul style="list-style-type: none"> —3/3 to 12/8 mm Hg —As much as 30 mm Hg in patients who are obese 	<ul style="list-style-type: none"> • Underestimation of blood pressure • Range of error: <ul style="list-style-type: none"> —10–30 mm Hg

Undercuffing is more common than overcuffing

Cuffing solutions

- Correction factors on the cuff
- Cuffs containing a variety of bladders of varying dimensions
- A universal cuff for all arms
- A cuff suitable for most arms

Recommended bladder dimensions for adults

British Hypertension Society

Cuff type	For whom	Dimensions (cm)
Small	Lean adult arms and children	12 × 18
Standard	Most adult arms	12 × 26
Large	Arms of obese patients	12 × 40

American Heart Association

Cuff type	Arm circumference (cm)	Dimensions (cm)
Small adult	22 – 26	12 × 22
Adult	27 – 34	16 × 30
Large adult	35 – 44	16 × 36
Adult thigh	45 – 52	20 × 42

Recommended bladder dimensions for children aged 0–14 years

Cuff type	Dimensions (cm)
1	4 × 13
2	8 × 18
3	12 × 26

Korotkoff sounds are not audible reliably in any child younger than one year and in many children younger than five years, so Doppler ultrasound or oscillometry should be used

ABC of hypertension

Body size is the most important determinant of blood pressure in childhood and adolescence. The US National High Blood Pressure Education Group on Hypertension Control in Children and Adolescents provides blood pressure ranges that relate to age and height.

Elderly people

In epidemiological and interventional studies, blood pressure predicts morbidity and mortality in elderly people as effectively as in the young. Elderly people have considerable variability in blood pressure, which can lead to a number of diurnal blood pressure patterns that are identified best with measurement of ambulatory blood pressure (see Part III).

Isolated systolic hypertension—This is the most common form of hypertension in elderly people.

Hypotension—Blood pressure in elderly people can vary greatly in those with autonomic failure, with periods of hypotension interspersed with hypertension on measurement of ambulatory blood pressure. As elderly people especially can be susceptible to the adverse effects of antihypertensive drugs, identification of postural hypotension particularly becomes important. Some elderly patients experience quite a marked decrease in blood pressure after eating, and this may be symptomatic. This again is diagnosed best by measurement of blood pressure when a patient is standing after a meal or with ambulatory blood pressure.

White coat hypertension—Elderly people are affected by the white coat phenomenon even more than young people.

Pseudohypertension—This term describes a large discrepancy between cuff and direct measurement of blood pressure in elderly patients. When conventional measurements seem to be out of proportion with the clinical findings, referral to a specialist cardiovascular centre for further investigation may be an appropriate option.

Causes of hypotension in elderly patients

- Standing—postural hypotension
- Autonomic failure
- Drugs
- Meals—post-prandial hypotension
- Diabetes mellitus
- Parkinson's disease

Obese people

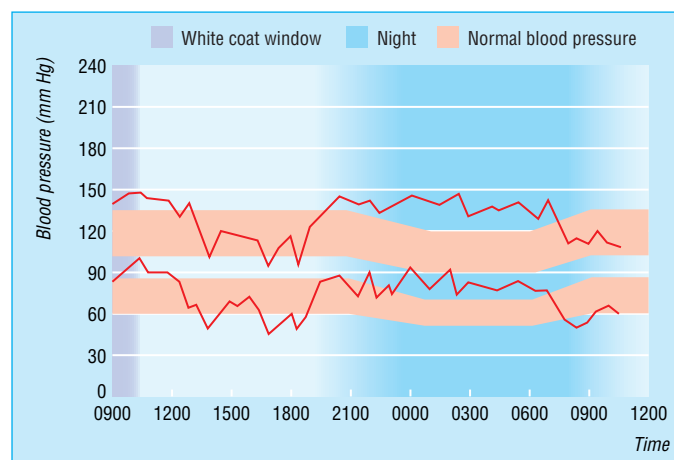
The association between obesity and hypertension has been confirmed in many epidemiological studies. Obesity may affect the accuracy of measurement of blood pressure in children, young and elderly people, and pregnant women. The relation of arm circumference to bladder dimensions is particularly important. If the bladder is too short, blood pressure will be overestimated—"cuff hypertension"—and if it is too long, blood pressure may be underestimated. The increasing prevalence of the metabolic syndrome, of which hypertension is a major component, means that accurate measurement of blood pressure increasingly becomes important.

Arrhythmias

Large variations in blood pressure from beat to beat make it difficult to obtain accurate measurements in patients with arrhythmias. In patients with arrhythmias such as atrial fibrillation, blood pressure varies depending on the preceding pulse interval. No generally accepted method of determining auscultatory endpoints in patients with arrhythmias exists.



Blood pressure can vary considerably in elderly people (photos.com)



Ambulatory blood pressure measurement in a patient with hypotension. Plot and report generated by dabl ABPM— © dabl 2006 (www.dabl.ie)

International Diabetes Federation's consensus worldwide definition of metabolic syndrome (2005)

- Central obesity—waist ≥ 94 cm in men and ≥ 80 cm in women for Europids (figures available for other races)
- Two of the following:
 - Raised triglycerides— ≥ 1.7 mmol/l (or treatment)
 - Low levels of high density lipoprotein cholesterol— < 1.04 mmol/l in men and < 1.29 mmol/l in women (or treatment)
 - High blood pressure— $\geq 130/85$ mm Hg (or treatment)
 - Fasting hyperglycaemia—glucose ≥ 5.6 mmol/l or previous diagnosis of diabetes or impaired glucose tolerance

Measurement of blood pressure

Devices for measuring blood pressure vary greatly in their ability to accurately record blood pressure in patients with arrhythmias. Measurements of blood pressure at best will constitute a rough estimate in those with atrial fibrillation, particularly when the ventricular rhythm is rapid or highly irregular, or both. The rate of deflation should be no faster than 2 mm Hg per heartbeat, and repeated measurements may be needed to overcome variability from beat to beat.

Two potential sources of error exist when patients have bradyarrhythmia. If the rhythm is irregular, the same problems as with atrial fibrillation will apply. When the heart rate is extremely slow—for example 40 beats per minute—it is important that the rate of deflation used is less than for people with normal heart rates, as too rapid deflation will lead to underestimation of systolic blood pressure and overestimation of diastolic blood pressure.

Pregnancy

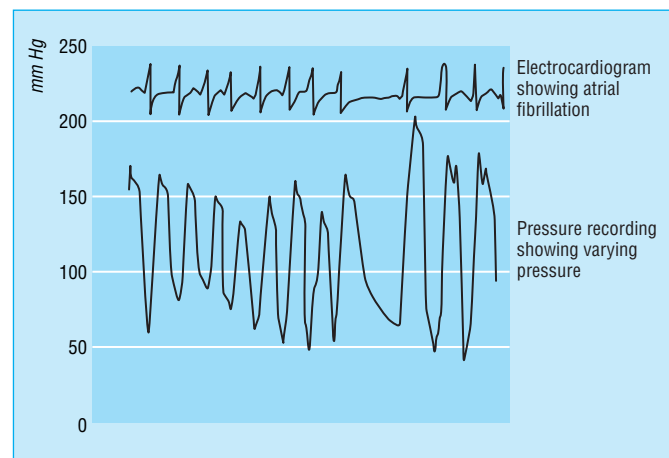
Clinically relevant hypertension occurs in more than 10% of pregnant women in most populations. High blood pressure is a key factor in medical decision making in pregnancy. Disappearance of sounds (fifth phase) is the most accurate measurement of diastolic pressure, except when sounds persist to zero, in which case the fourth phase of muffling of sounds should be used.

Patients who take antihypertensive drugs

In patients who take antihypertensive drugs, the timing of measurement may have a substantial influence on the blood pressure. The time of taking antihypertensive drugs should be noted.

Blood pressure in patients who are exercising

Systolic blood pressure increases with increasing dynamic work as a result of increasing cardiac output, whereas diastolic pressure usually remains about the same or moderately lower. An exaggerated blood pressure response during exercise may predict development of future hypertension.



Atrial fibrillation



Taking the blood pressure of a pregnant woman

ABC of hypertension

Part II Conventional sphygmomanometry

Basic requirements for auscultatory measurement of blood pressure

The century old technique of Riva Rocci/Korotkoff is now recognised to be fraught with inaccuracies that may lead to the misdiagnosis of abnormal blood pressure in many people. As a result, the auscultatory technique is being replaced by automated techniques, and its place in medicine may soon be of historical rather than practical interest. Measurement of blood pressure in clinical practice is dependent on the accurate transmission and interpretation of a signal (the Korotkoff sound or pulse wave) from a patient through a device (the sphygmomanometer) to an observer. Errors in measurement can occur at any interaction point during the technique, but the observer is by far the most fallible component.

Observer error

The major cause of observer error is the variability of blood pressure and the misleading measurements that constitute the phenomena of white coat hypertension and masked hypertension now may be added to this list. Training of observers in the technique of auscultatory measurement of blood pressure is often taken for granted. Instruction to medical students and nurses has not always been as comprehensive as it might be, and assessment for competence in the measurement of blood pressure has been a relatively recent development. A number of training methods exist.

Mercury and aneroid sphygmomanometers

The mercury sphygmomanometer is a reliable device, but all too often its continuing efficiency has been taken for granted. Aneroid manometers are not as accurate. These two types of device have certain features in common; these are:

Inflation-deflation system

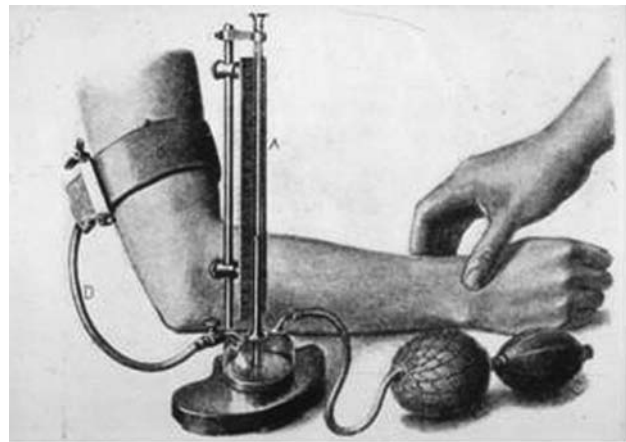
The inflation-deflation system consists of an inflating and deflating mechanism connected by rubber tubing to an occluding bladder. The standard mercury and aneroid sphygmomanometers used in clinical practice are operated manually, with inflation by means of a bulb compressed by hand and deflation by means of a release valve, which is also controlled by hand. The pump and control valve are connected to the inflatable bladder and to the sphygmomanometer. One of the most common sources of error in sphygmomanometers is the control valve.

Mercury sphygmomanometers

The mercury sphygmomanometer is a simple and accurate device that can be serviced easily, but concerns rightly exist about the toxicity of mercury for people who use mercury sphygmomanometers and those who service them. The greatest concern about mercury, however, is its toxic effect on the environment, and mercury increasingly is being banned from use in medicine.

Aneroid sphygmomanometers

Aneroid sphygmomanometers register pressure through a bellows and lever system that is more intricate mechanically than the mercury reservoir and column. The jolts and bumps of



Riva-Rocci sphygmomanometer. Reproduced from O'Brien E, Fitzgerald D. The history of indirect blood pressure measurement. In: *Blood pressure management* O'Brien E, O'Malley K, eds. Amsterdam: Elsevier, 1991

Observer influences

- Systematic error—*intraobserver* and *interobserver* error
- Terminal digit preference—rounding off to favoured digit, usually 0
- Observer prejudice—choice of measured pressure influenced by what observer wishes it to be
- White coat hypertension—high office and normal daytime ambulatory blood pressure
- Masked hypertension—normal office and high daytime ambulatory blood pressure

Training methods

- Direct instruction with a binaural or multiaural stethoscope
- Manuals, booklets and guidelines
- Audiotapes, CD-Rom, and DVD with instruction and visual falling mercury column and Korotkoff sounds permitting assessment of competence



Mercury sphygmomanometer

Measurement of blood pressure

Features and weaknesses common to mercury and aneroid sphygmomanometers

Features

- Inflation-deflation system
- Occluding bladder encased in a cuff
- Auscultation of Korotkoff sounds with stethoscope
- Connecting rubber tubing

Weaknesses

- Defective control valve—leakage:
 - Underestimation of systolic blood pressure
 - Overestimation of diastolic blood pressure
- Leaks as a result of cracked or perished rubber:
 - Mercury fall cannot be controlled
- Inadequate tubing:
 - Minimum length of 70 cm between cuff and manometer
 - Minimum length of 30 cm between pump and cuff
- Connections not airtight



Aneroid gauge. With permission from Miriam Maslo/Science Photo Library

everyday use affect accuracy over time, which usually leads to falsely low readings and thus underestimations of blood pressure. They are therefore less accurate in use than mercury sphygmomanometers. Moreover, aneroid sphygmomanometry is also prone to all the problems of the auscultatory technique. As mercury sphygmomanometers are removed from clinical practice, people tend to replace them with aneroid devices on the false assumption that they are equally accurate. Remarkably little literature exists on the accuracy of aneroid devices and what does exist is generally negative (see www.dableducational.org).

Stethoscope

A stethoscope should be of high quality, with clean and well fitting earpieces. Whether the bell or diaphragm is used in routine measurement of blood pressure probably does not matter much, as long as the stethoscope is placed over the palpated brachial artery in the antecubital fossa. As the diaphragm covers a larger area and is easier to hold than a bell endpiece, it is reasonable to recommend it for routine clinical measurement of blood pressure.



Placement of stethoscope. With permission from Sheila Terry/Science Photo Library

Maintenance

To check and maintain mercury sphygmomanometers is easy, but great care should be taken when mercury is handled. Mercury sphygmomanometers need cleaning and checking at least every six months in hospital use and every 12 months in general use. In practice, doctors often neglect to have sphygmomanometers checked and serviced. The responsibility for reporting faulty equipment or lack of appropriate cuffs lies with the observer, who should always refuse to use defective or inappropriate equipment.

Aneroid sphygmomanometers should be checked every six months against an accurate mercury sphygmomanometer over the entire pressure range. This can be done by connecting the aneroid sphygmomanometer via a Y piece to the tubing of the mercury sphygmomanometer and inflating the cuff around a bottle or cylinder. If inaccuracies or other faults are found, the instrument must be repaired by the manufacturer or supplier.

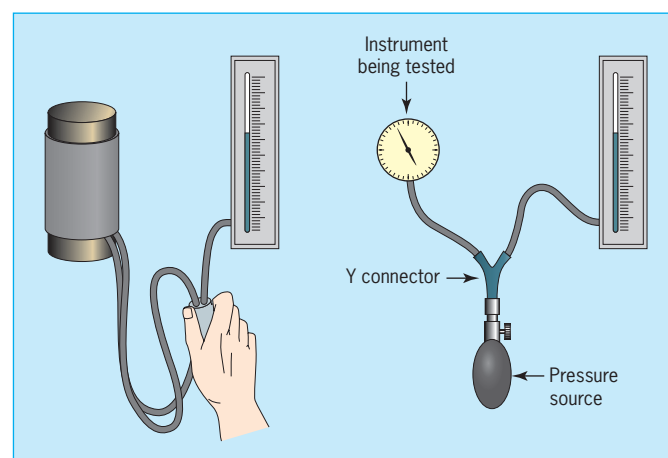
Alternative devices to mercury sphygmomanometers

Non-automated devices

Oscillometric measurement of blood pressure has a number of inherent limitations. It is therefore unlikely to be accepted as the gold standard for conventional measurement of blood pressure.

Accuracy limits

- Difference in accuracy of aneroid *v* mercury sphygmomanometer <3 mm Hg
- Surveys have shown:
 - 58% aneroid devices have errors >4 mm Hg
 - 30% aneroid devices have errors >7 mm Hg
 - 50% hospital sphygmomanometer are defective
- Maintenance policy is mandatory but rarely in place



Calibration of aneroid sphygmomanometer

ABC of hypertension

Alternative devices to the mercury sphygmomanometer, which combine the features of electronic and mercury devices by using an electronic pressure gauge as a substitute for the mercury column, are now being produced. These devices, which are known as “hybrid” sphygmomanometers, display cuff pressure as a simulated mercury column with an array of liquid crystal displays and as a digital readout on a liquid crystal display. The cuff is deflated in the normal way; when systolic and diastolic pressure are heard, a button next to the deflation knob is pressed, which freezes the digital display to show systolic and diastolic pressures. This therefore offers the potential of eliminating terminal digit preference, which is a major problem with the clinical use of any auscultatory monitor. The observer is therefore able to measure blood pressure with the traditional auscultatory technique without necessarily having to rely on automated readings. This is achieved without the problems associated with mercury columns or aneroid devices.

Automated devices

As technology improves, mercury and aneroid devices will soon be replaced by accurate automated sphygmomanometers.



Mercury free sphygmomanometer

Advantages and disadvantages of automated devices

Advantages

- Provide printouts with:
 - Systolic and diastolic blood pressure
 - Mean blood pressure
 - Heart rate
 - Time of measurement
 - Date of measurement
- Eliminate observer error
- Eliminate observer bias
- Eliminate observer digit preference
- Minimal training needed
- Store data for future analysis and comparison
- Ability to plot trends

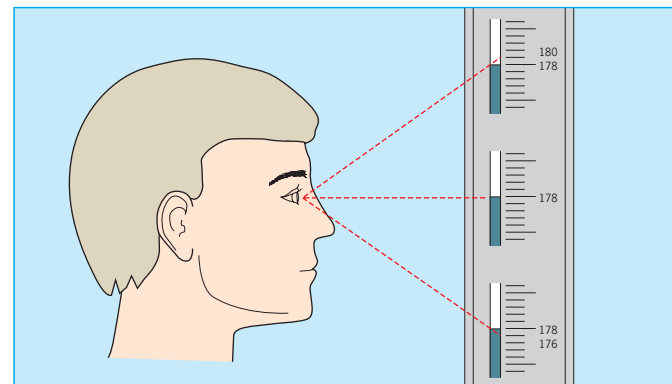
Disadvantages

- Poor record for accuracy but improving
- Designed for self measurement rather than clinical use
- All use oscillometric measurement
 - Point of maximal cuff oscillation—mean blood pressure
 - Systolic and diastolic blood pressure derived from algorithm
 - Details of algorithm known only to manufacturer
- Oscillometric technique fails in some individuals
- Oscillometric technique not accurate in rapid atrial fibrillation

Performing auscultatory measurements

Position of manometer

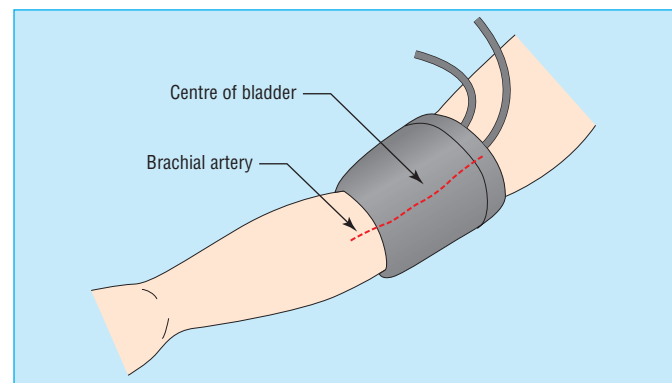
The observer should take care to position the manometer so that the scale can be read easily. Accurate measurement is achieved most effectively with stand mounted models, which can easily be adjusted to suit the height of the observer. The mercury manometer has a vertical scale, and errors will occur unless the eye is kept close to the level of the meniscus. The aneroid scale is a composite of vertical and horizontal divisions and numbers, and it must be viewed straight on, with the eye on a line perpendicular to the centre of the face of the gauge.



Eye level

Placement of cuff

The cuff should be wrapped around the arm, ensuring that the dimensions of the bladder are accurate. If the bladder does not completely encircle the arm, its centre must be over the brachial artery. The rubber tubes from the bladder are usually placed inferiorly, often at the site of the brachial artery, but placing them superiorly allows easy access to the antecubital fossa for auscultation. The lower edge of the cuff should be 2–3 cm above the point of brachial artery pulsation.



Placement of cuff

Palpatory estimation of blood pressure

The brachial artery should be palpated while the cuff is inflated rapidly to about 30 mm Hg above the point where the pulse disappears; the cuff is then deflated slowly, and the observer notes the pressure at which the pulse reappears.

Measurement of blood pressure

This is the approximate level of the systolic pressure. Palpatory estimation is important, because phase I sounds sometimes disappear as pressure is reduced and reappear at a lower level (the auscultatory gap), which results in systolic pressure being underestimated unless already determined by palpation. The palpatory technique is useful in patients in whom auscultatory endpoints may be difficult to judge accurately, for example, pregnant women, patients in shock, and those who are exercising. (The radial artery is often used for palpatory estimation of the systolic pressure but use of the brachial artery also allows the observer to establish its location before auscultation begins.)

Diastolic dilemma

For many years recommendations on blood pressure measurement have been uncertain about the diastolic endpoint—the so called diastolic dilemma. Phase IV (muffling) may coincide with or be as much as 10 mmHg higher than phase V (disappearance), but usually the difference is less than 5 mmHg. Disappearance of sounds (phase V) should be taken as diastolic pressure. When the Korotkoff sounds persist down to zero, muffling of sounds (phase IV) should be recorded for diastolic pressure, and a note made to this effect.

Recording blood pressure

To make measurement of conventional blood pressure more informative and accurate, it is important to record the circumstances of measurement as well as the levels of blood pressure recorded. Reliability of measurement is improved if repeated measurements are made and measurement of ambulatory blood pressure or self-measurement of blood pressure, or both, gives much valuable information that cannot be obtained with measurement of conventional blood pressure.

Points to be noted

- Measurements should be noted to the nearest single mm Hg, without rounding off to the nearest 5 or 10 mm Hg
- Note state of patient (anxious or relaxed)
- Decide position of patient for measurement—lying, sitting, or standing
- Decide on arm (right or left) in which to measure blood pressure; readings should be taken in both arms at the first visit
- Note arm circumference
- Note inflatable bladder dimensions
- Identify Korotkoff phases IV and V for diastolic pressure
- Note presence of auscultatory gap
- Note time of drug ingestion, if appropriate
- At least two measurements should be taken at each visit at intervals of at least one minute

Korotkoff sounds

- **Phase I**—the first appearance of faint, repetitive, clear tapping sounds that gradually increase in intensity for at least two consecutive beats is the systolic blood pressure
- **Phase II**—a brief period may follow phase I, during which the sounds soften and acquire a swishing quality
- **Auscultatory gap**—in some patients, sounds may disappear altogether for a short time
- **Phase III**—the return of sharper sounds that become crisper to regain, or even exceed, the intensity of the sound in phase I. The clinical significance, if any, of phases II and III has not been established
- **Phase IV**—the distinct abrupt muffling of sounds, which become soft and blowing in quality
- **Phase V**—the point at which all sounds finally disappear completely is the diastolic pressure

Manometer position

- Manometer <3 feet from observer
- Mercury column should be vertical
- Mercury column at eye level—standard mounted models can be adjusted to suit the height of the observer
- Observer's eye should follow the level of the mercury meniscus
- Aneroid scale must be viewed straight on with eye on a line perpendicular to the centre of the face of the gauge

Steps in measurement

- Place the stethoscope gently over the brachial artery at the point of maximal pulsation
- Hold stethoscope firmly and evenly but without excessive pressure—excess pressure may distort artery and produce sounds below diastolic pressure
- Stethoscope end-piece should not touch clothing, cuff, or rubber tubes to avoid friction sounds
- Inflate cuff rapidly to about 30 mm Hg above palpated systolic pressure
- Deflate cuff at a rate of 2 to 3 mm Hg per pulse beat (or per second) during which the Korotkoff sounds will be heard
- Deflate cuff rapidly after all sounds disappear
- Make sure cuff is completely deflated before repeating measurement so as to avoid venous congestion of the arm

ABC of hypertension

Part III Ambulatory blood pressure measurement

Ambulatory blood pressure measurement is used increasingly in clinical practice. The evidence that it gives information over and above measurement of conventional blood pressure has been increasing steadily over the past 25 years. Ambulatory blood pressure measurement is now accepted internationally as an indispensable investigation in patients with established and suspected hypertension.

Choosing devices and software

The first step in adopting ambulatory blood pressure measurement is to select an accurate device (see www.dableducational.org for the latest selection of accurate devices). Ambulatory blood pressure measurement in clinical practice is simplified by a standardised graphical presentation of the recording (much as is the case for electrocardiograph recordings) regardless of the type of monitor used. This saves the user having to become familiar with a variety of programs and simplifies the interchange of recordings between hospitals and primary care practices. Interpretive reports provide help for doctors and nurses unfamiliar with the technique, and the time needed for a doctor to report on each measurement is reduced, which lessens the cost of the technique.

Financial considerations

Analysis of the cost-benefit of ambulatory blood pressure measurement is complex and awaits full study. It is more expensive than measurement of conventional blood pressure, but the evidence strongly suggests benefits to patients justify the additional expense.

Training requirements

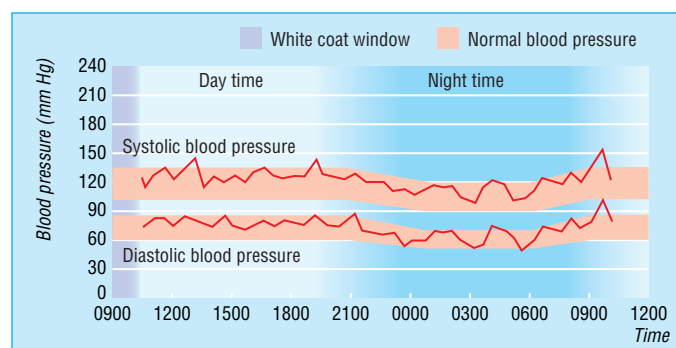
Measurement of ambulatory blood pressure is a specialised technique and should be approached with the care reserved for any such procedure. An understanding of the principles of the measurement of conventional blood pressure, cuff fitting, monitor function, and analysis and interpretation of the data produced is needed. In practice, a nurse with an interest and experience in hypertension can master the use of devices to measure ambulatory blood pressure after relatively little training. Analysis and interpretation of profiles for ambulatory blood pressure, however, need experience in the technique; this is achieved best by the doctor in charge of a service that provides ambulatory blood pressure measurement.

Using a monitor

Time needs to be allowed to fit the monitor and prepare the patient for the monitoring period if good results are to be obtained. The key to successful measurement of ambulatory blood pressure is educating the patient on the process of monitoring, and the instructions should be explained and printed on a diary card. Blood pressures recorded during the 24 hours can be analysed in a number of ways, which can be selected in the software program. One simple and popular method is to assess the time of awakening and sleeping from entries in diary cards. Another method uses fixed times, in which the retiring period (2101 to 0059) and rising period



Devices to measure ambulatory blood pressure



Plot of ambulatory blood pressure. Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)

Financial considerations in measurement of ambulatory blood pressure

Against

- Devices remain expensive but are becoming cheaper
- Staff need to be trained on the use and interpretation of data
- Staff need to fit monitors, instruct patients, and download data from recorders

In favour

- Identifies patients with white coat hypertension and masked hypertension
- Reduces drug prescribing
- Helps decision making for insurance proposals
- Helps decision making for employers
- Shows efficacy of treatment
 - More efficient prescribing of drugs
 - Decreased prescribing of drugs
- Identifies patients with nocturnal hypertension at high risk for stroke
- Predicts outcome more accurately than other blood pressure measurements

Using a monitor to measure ambulatory blood pressure

- 15–30 minutes needed
- Patient should be relaxed in quiet room
- Enter patient details into monitor
- Measure blood pressure in each arm
 - If difference in systolic blood pressure <10 mm Hg, use non-dominant arm
 - If difference in systolic blood pressure ≥10 mm Hg, use higher pressure arm
- Select appropriate cuff
- Select frequency of measurement—usually every 30 minutes day and night
- Inactivate liquid crystal display
- Give patient written instructions and a diary card
- Instruct patient on how to remove and inactivate monitor after 24 hours

Measurement of blood pressure

(0601 to 0859; during which blood pressure is subject to considerable variation) are eliminated. The daytime period lasts from 0900 to 2100 and the night-time period from 0100 to 0600. In this way, variations between young and old people and between people of different cultures are eliminated, to some extent, from the analysis.

The reproducibility of measurements of ambulatory blood pressure is improved when the measurements are taken on like days—for example, working days or recreational days. A diary card may be used to record symptoms and events that could influence ambulatory blood pressure measurement.

Editing data

Many statistical techniques exist to describe different aspects of ambulatory records, and no one method is ideal. If sufficient measurements are available, editing is not needed to calculate average values for 24 hours, daytime, and night-time. Only grossly incorrect readings should be deleted from recordings.

Normal levels

As with the measurement of conventional blood pressure, normal ranges for ambulatory blood pressures have been the subject of much debate over the years. General agreement is that levels of ambulatory blood pressure are appreciably lower than normal levels for conventional blood pressure.

Clinical indications

Ambulatory blood pressure measurement provides a large number of measurements over a period of time, usually 24 hours, which can be plotted to give a profile of the behaviour of a person's blood pressure. In practice, although the average daytime or night-time values from ambulatory blood pressure measurement are used to make decisions, the clinical use of ambulatory blood pressure has identified a number of phenomena in hypertension.

Suspected white coat hypertension

White coat hypertension, or isolated office hypertension, is present in people who seem to have hypertension from measurement of conventional blood pressure but have normal ambulatory blood pressure. The most popular definition of white coat hypertension requires:

- blood pressure measured by conventional techniques in the office, clinic, or surgery $>140/90$ mm Hg on at least three occasions
- normal ambulatory blood pressure throughout the 24 hours, except for the first hour, when the patient is under the pressor influence of the medical environment while having the monitor fitted.

White coat hypertension is present in 10–20% of clinic referrals for ambulatory blood pressure measurement; the reported prevalence in the population is around 10%. Patients with high conventional blood pressure and normal average daytime ambulatory pressures have a higher risk of major cardiovascular events than those with clinically normal blood pressure and a lower risk than those with high pressures during the daytime. White coat hypertension may affect young people, elderly people, people with normal blood pressure, those with hypertension, and pregnant women.

White coat effect

White coat hypertension should be distinguished from white coat effect, which is the term used to describe the increase in

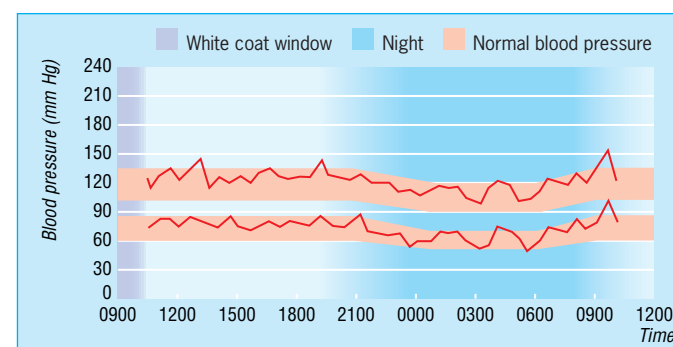
Requirements for satisfactory measurement of ambulatory blood pressure

- Measurements taken every 30 minutes day and night
- Measurements sometimes taken every 15 minutes
 - Can interfere with activity during the day
 - Can interfere with sleep at night
- Daytime minimum—14 measurements of systolic and diastolic blood pressure
- Night-time minimum—seven measurements of systolic and diastolic blood pressure
- If minimum requirement not met, measurement should be repeated

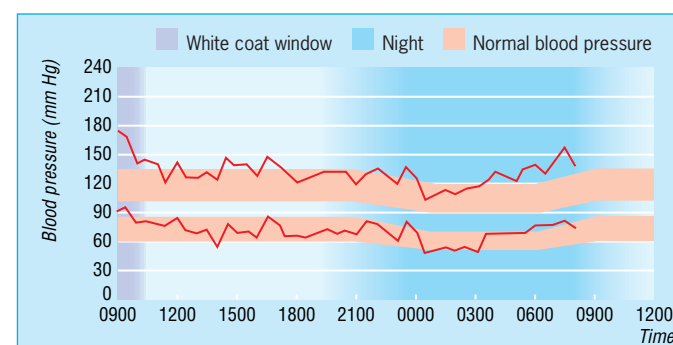
Recommended normal levels for ambulatory blood pressure in adults*

Status	Blood pressure (mm Hg)		
	Optimal	Normal	Abnormal
Awake	$< 130/80$	$< 135/85$	$> 140/90$
Asleep	$< 115/65$	$< 120/70$	$> 125/75$

*Normal and abnormal demarcation levels based on evidence from several studies. Evidence not available to make recommendations for intermediate pressure ranges between normal and abnormal levels or for recommendations lower than those given. The levels are only a guide to normality, and lower optimal levels may be more appropriate in patients whose total profile of cardiovascular risk factors is high, and those with comorbid disease.



Normal ambulatory blood pressure monitoring pattern—On the basis of the data recorded and the available literature, the ambulatory blood pressure monitoring pattern suggests normal 24-hour systolic and diastolic blood pressure (128/78 mm Hg daytime, 110/62 mm Hg night-time). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)



White coat hypertension—On the basis of the data recorded and the available literature, the ambulatory blood pressure monitoring pattern suggests white coat hypertension (175/95 mm Hg) with otherwise normal 24-hour systolic and diastolic blood pressure (133/71 mm Hg daytime, 119/59 mm Hg night-time). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)

Consequences of failing to identify white coat hypertension

- People penalised for insurance and pension policies and employment
- Lifelong treatment prescribed unnecessarily
- Adverse effects of drugs more likely
- Inappropriate use of drugs in elderly people, with possible debilitating consequences

ABC of hypertension

pressure that occurs in the medical environment regardless of the daytime ambulatory blood pressure. It is present in most patients with hypertension, who usually tend to have conventional blood pressures higher than the average daytime ambulatory blood pressure, which is still higher than normal.

Masked hypertension (isolated ambulatory hypertension)

Recently, patients in whom conventional blood pressure is normal but ambulatory blood pressure is high have been identified. Because ambulatory blood pressure gives a better classification of risk than conventional blood pressure, these people should be regarded genuinely as being hypertensive and at risk. The problem for doctors in clinical practice is how to identify and manage these patients, who may number as many as 10 million people in the United States.

Resistant hypertension

Ambulatory blood pressure may be useful in patients with resistant hypertension (conventional blood pressure consistently >150/90 mm Hg despite treatment with three antihypertensive drugs). It may indicate that the apparent lack of response is the result of the white coat phenomenon.

Elderly patients in whom treatment is being considered

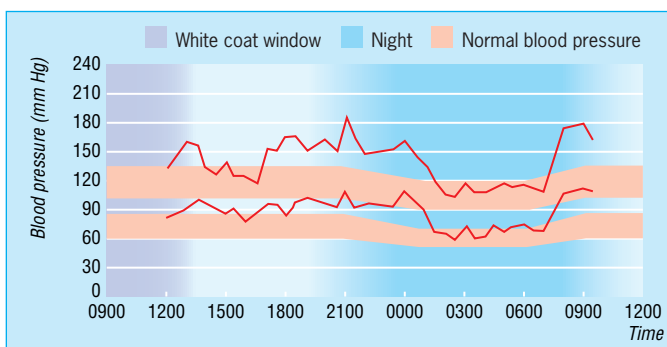
A number of patterns of ambulatory blood pressure may be found in elderly people. Conventional systolic blood pressure in elderly people may be an average of 20 mm Hg higher than daytime ambulatory blood pressure. A number of hypotensive states as a result of baroreceptor or autonomic failure are common in elderly people. As elderly people particularly can be susceptible to the adverse effects of drugs used to reduce blood pressure, identification of hypotension becomes especially important, although its management may present a considerable therapeutic challenge.

Isolated diastolic hypertension

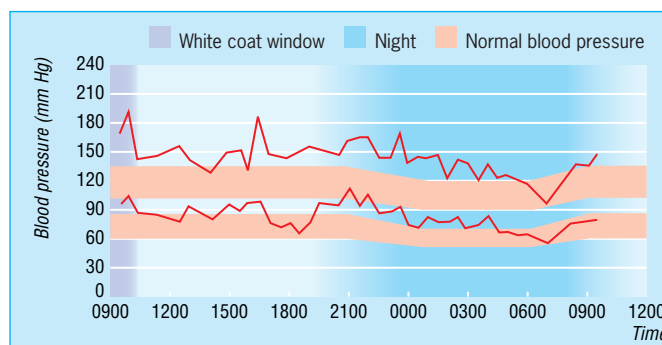
High diastolic blood pressure with normal systolic ambulatory blood pressure increasingly is being recognised. The importance of isolated diastolic hypertension awaits further research.

Suspected nocturnal hypertension

Ambulatory blood pressure measurement allows blood pressure to be measured during sleep. Recent evidence showed that people whose blood pressure remains high at night (non-dippers) rather than falling below daytime levels (as in most people) are at higher risk of stroke, heart attack, and cardiovascular death. The pattern of non-dipping may provide



Hypertensive dipper. On basis of recorded data and available literature, ambulatory blood pressure suggests mild daytime systolic and diastolic hypertension (147/93 mm Hg) and normal night-time systolic and diastolic blood pressure (111/66 mm Hg) with white coat effect (158/90 mm Hg). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)



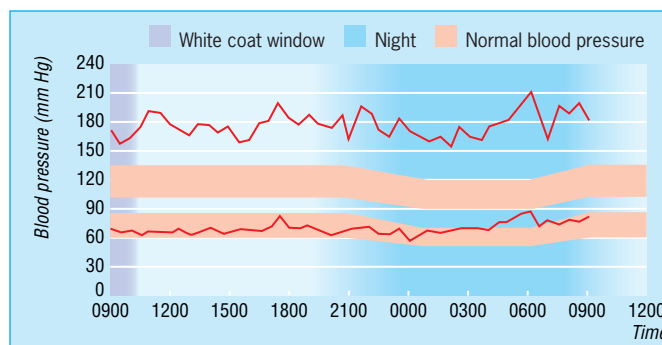
White coat effect—On the basis of the data recorded and the available literature, the pattern suggests mild daytime systolic hypertension (149 mm Hg), borderline daytime diastolic hypertension (87 mm Hg), borderline night-time systolic hypertension (121 mm Hg), and normal night-time diastolic blood pressure (67 mm Hg) with white coat effect (187/104 mm Hg). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)

Factors suspicious for masked hypertension

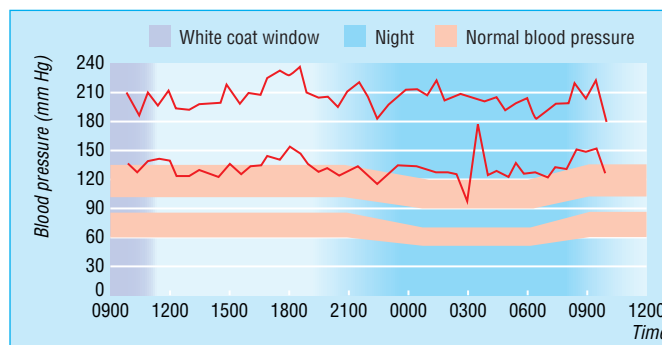
- High conventional blood pressure recorded at some time
- Normal or normal-high conventional blood pressure and early left ventricular hypertrophy in a young patient
- Family history of hypertension in two parents
- Multiple risks for cardiovascular disease
- Diabetes

Patterns of ambulatory blood pressure in elderly people

- White coat hypertension (common)
- Masked hypertension
- Isolated systolic hypertension (most common)
- Nocturnal hypertension
- Autonomic or baroreceptor failure (daytime hypotension or nocturnal hypertension)
- Postural hypotension
- Drug induced hypotension
- Postprandial hypotension



Isolated systolic hypertension—On basis of recorded data and available literature, the pattern suggests severe 24-hour isolated systolic hypertension (176/68 mm Hg daytime, 169/70 mm Hg night-time). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)



Hypertensive non-dipper—On basis of recorded data and available literature, the pattern suggests severe systolic and diastolic hypertension over 24 hours (209/135 mm Hg daytime and 205/130 mm Hg at night). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)

Measurement of blood pressure

a useful (although non-specific) clue to the presence of secondary hypertension in a patient.

Pregnancy

As in the non-pregnant state, the main use for ambulatory blood pressure measurement in pregnancy is to identify white coat hypertension, which may occur in nearly 30% of pregnant women. 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 changes in pressure, which occur during the trimesters of pregnancy and the postpartum period, have been defined.

Type I diabetes

In people with type I diabetes, a blunted or absent drop in blood pressure from day to night is an even more serious predictor for increased cardiovascular complications than in patients with hypertension without diabetes. The aim of antihypertensive drugs should be to achieve lower levels of blood pressure in diabetic than in non-diabetic patients.

Ambulatory hypotension

Ambulatory blood pressure measurement is helpful in identifying hypotensive episodes in elderly people, but it also may be used in young patients in whom hypotension is suspected as a cause of symptoms. Ambulatory blood pressure measurement may also show drug induced decreases in blood pressure in patients being treated for hypertension.

Who should be monitored

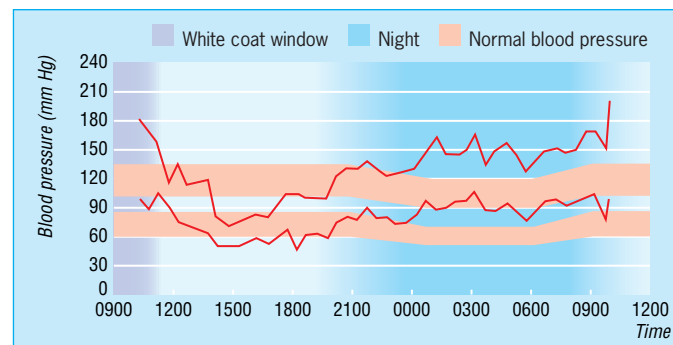
Ambulatory blood pressure measurement may be inconvenient to patients and should be used, therefore, with discretion. The decision as to when to repeat ambulatory blood pressure measurement is largely one of clinical judgment. The frequency of repeat ambulatory blood pressure measurement must be guided by the response to treatment, the stability of blood pressure control, and the overall cardiovascular risk profile. Where the risk for cardiovascular complications is high, the frequency is more than justified by the need for tight blood pressure control, whereas when the risk is low, less frequent measurement is needed. Self-measurement of blood pressure may be combined with ambulatory blood pressure measurement to reduce the frequency of the latter.

Indications for re-monitoring for ambulatory blood pressure measurement

- Subjects with white coat hypertension
- Treated patients with major white coat effect
- Elderly patients with symptoms suggesting orthostatic hypotension
- Patients with nocturnal hypertension
- To compare effect of changes in medication
- High-risk patients
- Diabetic patients

Mean (SD) ambulatory blood pressures during pregnancy

Gestation (weeks)	Blood pressure (mm Hg)			
	Daytime		Night-time	
	Systolic	Diastolic	Systolic	Diastolic
9–16	115 (8)	70 (7)	100 (7)	55 (5)
18–24	115 (8)	69 (6)	99 (8)	54 (6)
26–32	116 (9)	70 (7)	101 (8)	55 (6)
33–40	119 (9)	74 (7)	106 (8)	58 (7)



Ambulatory hypotension—On basis of recorded data and available literature, ambulatory blood pressure monitoring pattern suggests low daytime systolic blood pressure (100 mm Hg) and normal daytime diastolic blood pressure (61 mm Hg) and moderate night-time systolic and diastolic hypertension (146/89 mm Hg) with white coat effect (200/102 mmHg). Plot and report generated by dabl ABPM—© dabl 2006 (www.dabl.ie)

The role of ambulatory blood pressure in guiding drug treatment is the subject of much research, but recent reviews have highlighted the potential of ambulatory blood pressure measurement over 24 hours in guiding the use of antihypertensive drugs

Ambulatory blood pressure measurement as a guide to drug treatment

- Efficacy of treatment in patients with white coat effect
- Efficacy of treatment over 24 hours—especially during the night
- Shows excessive effects of drugs matched to occurrence of symptoms
- Shows drug induced hypotension

Suggested frequency for repeat ambulatory blood pressure measurement

- White coat hypertension pattern—confirm diagnosis in 3–6 months
- White coat pattern and low risk profile—repeat ambulatory blood pressure measurement every 1 to 2 years
- White coat hypertension pattern and high risk profile—repeat ambulatory blood pressure measurement every 6 months to detect possible transition to sustained hypertension requiring treatment
- To determine efficacy of treatment
 - If low risk and controlled without target organ damage—annual ambulatory blood pressure measurement
 - If high risk and/or poorly controlled with target organ damage—more frequent ambulatory blood pressure measurement

ABC of hypertension

Part IV Self-measurement of blood pressure

For more than 50 years, self-measured blood pressures in the home have been recognised to be lower than those recorded by a doctor. Self-measurement is popular with the public, as evidenced by the huge sales of devices for self-monitoring. Doctors have tended to be cautious in their use of the technique, but interest in self-measurement of blood pressure is reviving, although the fact that much research is needed is recognised.

General considerations

Devices and validation

Monitors for self-measurement of blood pressure include mercury column sphygmomanometers, aneroid manometers, and electronic semi-automatic or automatic devices. The sale of electronic devices designed for self-measurement of blood pressure is not necessarily subject to any medical influence. This freedom from medical control, coupled with a growing public desire to know more about health and illness, has resulted in the manufacture and marketing of a vast array of such devices, few of which have been evaluated according to the procedures considered necessary for equipment used to measure blood pressure in clinical practice.

Automated devices available for self-measurement all use the oscillometric technique. Three categories are available: devices that measure blood pressure in the upper arm, wrist, or finger.

Lack of popularity for self-measurement

- Patients need to be trained in the technique
- Technique subject to bias by patients (can be overcome with printouts from device)
- May cause anxiety to certain patients
- May make some patients obsessive about levels of blood pressure
- Devices largely have not been validated
- Most devices have been inaccurate (this is changing for the better)
- Lack of evidence to support use of the technique
- Not suitable for patients with certain disabilities



Selection of devices for self-measurement of blood pressure

Accuracy of wrist devices for self-measurement of blood pressure

Device	AAMI	BHS	ESH	Circumstance	Recommendation
Braun PrecisionSensor BP2000	Pass			At rest, manufacturer assistance	Questionable
Braun PrecisionSensor BP2550	Pass	B/B		Recruitment violation (AAMI)	Questionable
		B/B		Recruitment violation and analysis errors (BHS)	Questionable
				Abstract, results of systolic pressure unclear	Questionable
Braun PrecisionSensor BP2550(UG)			Pass/pass	At rest	Recommended
Braun VitalScan	Pass			Abstract; version not stated	Questionable
Braun VitalScan Plus 1650			Pass	Abstracts	Questionable
Omron 637IT	Pass	B/A	Fail/pass	Abstract; BHS 'pass' incorrectly reported	Questionable
				Ad hoc protocol, with or without position sensor, standard protocol projections inconclusive	Questionable

AAMI = American Association of Medical Instrumentation; BHS = British Hypertension Society; ESH = European Society for Hypertension.
Table adapted from dabl@ Educational Trust.

User procedure

The same principles apply to self-measurement as apply to measurement in general. Some points, however, need emphasis.

Use in primary care

At present, self-measurement of blood pressure is performed mostly by patients on their own initiative, with devices bought on the free market without medical control. Primary care doctors should see self-measurement as a means of gaining further insight into control of blood pressure and the effects of management strategies in motivated and informed patients who remain under medical supervision.

The website [dableducational](http://dableducational.org) shows the latest selection of accurate devices for self-measurement. See example table—for full details go to www.dableducational.org

Advantages of current devices for self-measurement

- Inexpensive
- Remove observer bias
- Eliminate terminal digit preference
- Provide printouts of data or store data:
 - Levels of systolic and diastolic blood pressures
 - Mean blood pressure
 - Heart rate
 - Time and date of measurements
 - Trend plots
- Provide electronic storage and transmission of data

Measurement of blood pressure

Frequency and timing of self-measurement

The frequency of self-measurement may vary according to the indication and the information that is sought. Frequent measurement may be recommended for individual patients (such as those with poor compliance) or for participants in pharmacological studies.

Diagnostic thresholds

The threshold level of 135/85 mm Hg for self-measurement of blood pressure is the same as that for mean daytime ambulatory blood pressure.

Clinical indications

The clinical applications of self-measurement of blood pressure are beginning to become apparent only as the technique is used more widely and scientific data is gathered.

White coat hypertension

Self-measurement has been proposed as a useful alternative to measurement of ambulatory blood pressure to detect white coat hypertension. The finding of normal blood pressure on self-measurement, however, does not rule out the possibility that the blood pressure may be higher at other times of the day. Self-measurement, which is less costly and more convenient than measurement of ambulatory pressure, may be appropriate for long term follow up of patients with white coat hypertension.

Guiding antihypertensive treatment

Self-measurement may have a role in assessing the response to antihypertensive drug treatment outside the medical environment and over time. Measurement of blood pressure in the home environment under similar everyday conditions avoids the white coat effect and reduces variability. Self-measurement can improve the assessment of blood pressure control in the management of hypertension and clinical trials. Recent systematic reviews have shown that self monitoring improves blood pressure control. Whether or not this is though improved adherence to drug treatment, by improved tailoring of drug treatment or by other methods is not fully established.

Elderly patients

Feasibility of self-measurement in elderly patients may be influenced by physical and intellectual limitations and the complexity of the chosen device. Studies in elderly people have shown that automatic equipment is more precise and easier to use than semi-automatic equipment.

Pregnancy

As in the general population, blood pressures recorded by self-measurement are lower than conventional blood pressures. Self-measurement may be useful for the diagnosis of white coat responders and to monitor the effect of antihypertensive drugs. Data storage and electronic transmission of data may have a particular role for patients who live at distance from the maternity clinic. Very few data are available, however, on levels of normality for self-measured blood pressure in the different stages of pregnancy and the use of the technique in pregnancy.

User procedure for self-measurement

- Self-measurement should be performed after five minutes' rest
- Use devices that occlude brachial artery
- Wrist monitors unreliable but improving
- Finger monitors should not be used
- Device cuff must be at level of heart on arm with highest blood pressure
- Patient diaries may be unreliable
- Devices equipped with memory, with possibility of storing or transmitting data, preferred
- Readings from first day should be discarded
- Use all other data to calculate mean blood pressure
- In patients with arrhythmias, self-measurement may not be appropriate
- Self-measurement should be under medical supervision
- Patients should be trained in self-measurement and re-evaluated annually
- Self-measurement is suited to patients motivated towards the management of their own health

Scheme for self-measurement

Phase	Directions
Start	<ul style="list-style-type: none"> • Initial period of seven days • Two measurements between 0600 and 0900 • Two measurements between 1800 and 2100 • Discard readings from first day of measurement, which are unrepresentative because of anxiety and unfamiliarity • Use average measurements as reference for treatment and follow up
Treatment	<ul style="list-style-type: none"> • Repeat the above when the patient is on treatment • Morning measurements should be made before drugs are taken (trough levels of drug) • Average of two weeks on treatment should be compared with average of commencement phase to determine efficacy • Averages of two weeks on each treatment regimen should be compared to determine efficacy after a <u>change in treatment</u>
Follow-up	<ul style="list-style-type: none"> • Two measurements on one day a week in patients with good control of blood pressure • More frequent measurements in patients with poor control of blood pressure or compliance

Diagnostic thresholds for self-measurement

- Data from longitudinal studies limited
- Reference values derived principally from statistical evaluation of databases
- Suggested upper limit of normality 135/85 mm Hg (average of multiple readings taken on several days)
- Optimal 130/80 mm Hg (average of multiple readings taken on several days)

Factors that influence self-measurement

- Observer prejudice (can be overcome with printouts and devices equipped with memory)
- Training of patients by doctors or nurses
- Training should focus on:
 - Use of device
 - Correct procedure
 - Interpretation of results
 - Need for maintenance and calibration
 - Essentials of hypertension
 - Management and treatment
- Seasonal variation (blood pressure is higher in winter and lower in summer)

ABC of hypertension

Diabetes

Increasing evidence shows that stringent control of blood pressure reduces the cardiovascular and microvascular complications of diabetes. Self-measurement of blood pressure may be an additional means of ensuring that such control is achieved, although no data are available yet to guide the use of self-measurement in patients with diabetes.

Resistant hypertension

Patients with apparently uncontrolled blood pressure according to conventional monitoring may have adequate control at home. It may be possible to identify at least some of these patients by self-measurement, although ambulatory blood pressure is the preferred technique. In the evaluation of patients with resistant hypertension but no signs of target organ damage, the first step might be to use self-measurement; if the levels of blood pressure are low, measurement of ambulatory blood pressure may then be indicated to confirm the degree of control.

Predicting outcome

Self-measurement may offer some advantage over measurement of conventional blood pressure in predicting cardiovascular outcome in hypertension, but data are extremely limited and the results of ongoing trials are awaited. The results of cross sectional studies have shown that the degree of left ventricular hypertrophy determined by electrocardiography and echocardiography is correlated more strongly with self-measurement than conventional measurement.

Clinical indications for self-measurement

Accepted indications

- Screening for white coat hypertension
- Long term follow up
- Improving compliance to treatment
- Resistant hypertension

Potential indications

- Hypertension in pregnancy
 - Hypertension in patients with diabetes
 - Hypertension in elderly patients
-

Poor compliance with treatment

- One of the most important causes of refractory hypertension
 - Self-measurement may provide patients with an understanding of high blood pressure and its response to treatment, thus improving compliance with treatment
-