Ambulatory versus home self-monitoring of blood pressure

Why both serve important roles

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The high level of misdiagnosis of hypertension that occurs with casual clinic measurement of blood pressure has led to most guidelines recommending out-of-office measurements. However, the choice between 24-hour ambulatory blood pressure monitoring, which is costly but robust, and patient self-monitoring at home, which is cheaper and more convenient, remains a difficult one.

Although measurement of blood pressure (BP) by a doctor in the clinic setting has long been the mainstay of determining whether a patient has hypertension, a high level of misdiagnosis has increasingly been recognised. This misdiagnosis occurs because of either the 'white-coat effect' or the presence of masked hypertension. The latter is considered to be the case when a patient is normotensive in the clinic but hypertensive at other times. The white-coat effect is a raised BP level in the presence of a doctor when the patient's BP is otherwise normal.

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Key points

- **Inaccuracies in casual clinic blood pressure (BP) measurements and subsequent misdiagnosis of hypertension make out-of-office BP assessment highly recommended for the diagnosis and management of hypertension.**
- **Out-of-office techniques involve either 24-hour assessment with an automated ambulatory BP monitoring (ABPM) device or a simpler patient-managed self-measurement protocol using a home BP monitoring (HBPM) device.**
- **ABPM is the gold standard as it is the most robust method for diagnosing 'white-coat' or masked hypertension and it takes nocturnal BP measurements, which are the best predictors of future cardiovascular events, but it is more expensive than HBPM.**
- **HBPM performed during the morning and evening across several days is cheaper and more convenient, making it the method preferred by patients and thereby increasing patient adherence.**
- **The threshold for diagnosing hypertension using either the daytime ABPM reading or HBPM readings is 135/85 mmHg.**
- **Both techniques have considerable cost–benefit and recommendations must include their use in conjunction with routine clinic BP assessment.**
- **ABPM is recommended initially for the correct diagnosis and assessment of the 24-hour BP profile, with HBPM used in the longer term for the maintenance phase of treatment or monitoring.**

Table. Comparison of ambulatory and home blood pressure monitoring

Ambulatory blood pressure monitoring	Home blood pressure monitoring
Advantages	**Advantages**
• Is less prone to misdiagnosis than clinic measurements	• Usually requires only two to three readings in the morning and evening for five to seven days
• Enables most reliable detection of white-coat and masked hypertension	• Enables some detection of white-coat and masked hypertension
• Provides a reliable guide to therapy effectiveness and can identify periods of the day when treatment may be insufficiently effective	• Provides a guide to therapy effectiveness
• Measures nocturnal dipping pattern in blood pressure level	• Is inexpensive and generally the patient's choice over ambulatory monitoring
• Can assess morning hypertension	• Can assess morning hypertension and long-term blood pressure and its variability
• Has standardised international protocols for validation and interpretation	• Has standardised international protocols for validation and interpretation
Disadvantages	**Disadvantages**
• Is expensive and not reimbursed in some countries, including Australia	• Does not assess nocturnal blood pressure
• Is not always available	• Has quality concerns because of self-measurement stress or selection bias
• Requires staff and patient training	• Requires some training of staff and patients to follow guidelines
• Can be uncomfortable if used over a long period	• Does not reflect the impact of daily activities on blood pressure (e.g. work stress)
• May disturb sleep	• Cannot be used by individuals with cognitive or physical disabilities

In-office BP measurements may also depend on who is taking them, with the values obtained by doctors being considerably higher than those taken by trained research staff or practice nurses.[1] In the recent Systolic Blood Pressure Intervention Trial (SPRINT), unattended automated office BP measurement with an Omron 907 device (Omron Healthcare) was used as a standard method of BP assessment.[2] The device was programmed for a five-minute rest period followed by three measurements of BP at one-minute intervals. BP values measured this way were considered to be 5 to 10 mmHg lower than with conventional measurement by doctors or nurses at a clinic.[3]

The Omron device is the same one that was given to all general practitioners through the High Blood Pressure Research Council of Australia's better BP measurement campaign in 2010, and it has been validated in the Australian setting.[4] Although this method may reduce some of the inadequacy of office BP measurement, unattended office measurements are not yet standard practice in Australia. Thus, there has been a recent shift in recommendations for the diagnosis of hypertension to include out-of-office BP measurement.[5-10]

Ambulatory or home blood pressure monitoring

Ambulatory BP monitoring (ABPM) is considered the most robust out-of-office method for determining an individual patient's BP, but there is increasing use of home BP monitoring (HBPM), where the patient measures their own BP. Both techniques have advantages and disadvantages (Table).

ABPM provides a 24-hour profile of a patient's BP pattern and, importantly, assesses whether the BP level dips appropriately at night. However, ABPM is expensive, not always available, can disturb sleep and requires considerable physician training and patient consultation.

HBPM is popular because it is convenient and cost effective, requiring an inexpensive device usually purchased from a pharmacy or online. HBPM involves the patient recognising their BP status, which is known to facilitate patient acceptance and adherence to treatment. On the downside, HBPM is less reliable than ABPM and does not assess nocturnal BP levels. Thus, although there are similarities between these technologies, there are also important differences.

Similarities

For the most part, oscillometric devices, where the pressure oscillations are measured during cuff deflation to determine mean BP level, are used for both ABPM and HBPM. The systolic and diastolic values are calculated using an algorithm based on the changing form of the oscillations. As such, the quality of the manufacturer's ability to equate the oscillometric measurement with the equivalent of the values that would be obtained by the traditional auscultatory method can differ considerably between devices and manufacturers. It is crucial that the device to be used for ABPM or HBPM has been validated by an appropriate standard testing procedure, such as that provided by the European Society of Hypertension.[11] Both techniques require the person to remain still during assessment, and they are similarly influenced by use of the correct cuff size. There are limitations with use of oscillometric devices in patients with arrhythmias, which can interfere with the correct determination of the BP level.[9] However, there are both home and ambulatory devices that can detect arrhythmias and avoid this problem.[12]

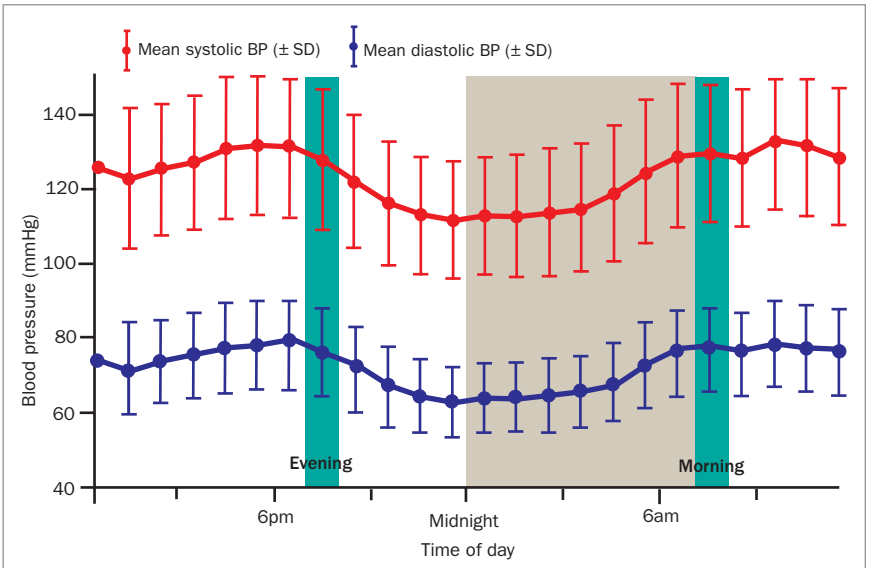


Figure. Pattern of hourly averages of systolic and diastolic blood pressure (BP) measured using ambulatory BP monitoring (ABPM) over 24 hours from a population study of 1533 people from Ohasama, Japan.[24] The green bands indicate the periods in the morning and evening when it is recommended that home BP measurements be taken.[25] The average morning and evening systolic BP values (both 129 mmHg) are the same as the overall average ABPM daytime systolic BP value (129 mmHg).

Differences

Despite these similarities, ABPM and HBPM are not equivalent.[13] ABPM is performed every 15 to 30 minutes during the day and night and measures BP over a 24-hour period. ABPM records the patient's BP level during their normal routine of daily activities, as well as towards the evening when BP levels are declining, during sleep, during the waking period and as the pressure surges towards the daytime peak. Thus, the patient may be standing, sitting or lying down during ABPM measurements.

On the other hand, several international guidelines recommend that HBPM should be performed at the same time of day, while the patient is sitting quietly after resting for five minutes, with dual measurements recorded in the morning (before taking medications) and in the evening over five to seven days.[7,10,13] However, HBPM does not measure BP during sleep. It is therefore a snapshot of two timepoints during the day and is likely to record BP levels during a period of relative inactivity.

Unlike the automated recording devices used for ABPM, HBPM can also be subject to patient bias, wherein preferred BP levels are recorded and others discarded.[14] However, this selection bias can be reduced by employing devices with internal memory.[15] A comparison of patient logbooks and device memory found that 90% of readings were recorded by the patient, and the difference between all readings and those recorded by the patient was minimal. However, fictional data were found in 16% of patient logbooks, indicating that HBPM results will be more accurate if devices with memory are used.[16] Clear patient instructions are also very important.

Comparison of values and diagnostic thresholds

Studies comparing ABPM and HBPM show that values from the latter are on average 5 mmHg lower for systolic BP, but diastolic BP values are similar between the two methods.[17-23] It could be suggested that the difference in systolic BP for HBPM is attributable to the selection of specific timepoints (morning and evening) when BP would be expected to be lower based on its pattern of changes over a 24-hour period. However, careful comparison from studies where both HBPM and ABPM were performed suggests that the average morning and evening systolic BP levels are similar to the overall daytime average systolic BP level (Figure).[24,25]

Any differences between ABPM daytime values and HBPM values have largely been ignored for setting the threshold for diagnosis of hypertension. The consensus from most major international hypertension guideline bodies, in Australia, Europe, the UK, Japan, USA and Canada, is that the threshold for diagnosis of hypertension should be set at 135/85 mmHg for both ABPM and HBPM.[7-10,26-28] A study that used a device in dual mode for both ABPM and HBPM found no clinically meaningful difference between ABPM daytime values and HBPM values. Thus, in practice, it is reasonable to consider the daytime ABPM and average HBPM values to be numerically equivalent.[29]

Diagnostic and prognostic value

Although one of the main reasons for using out-of-office measurements has been to detect white-coat and masked hypertension, the ability of the two methods to detect these conditions is not the same. HBPM has lower sensitivity but higher specificity compared with ABPM, and therefore has low positive and high negative predictive values for detecting white-coat, masked and sustained hypertension.[30] This means that, compared with ABPM, more than half of patients with white-coat hypertension are not accurately detected with HBPM.[30] Using HBPM instead of ABPM can lead to missing the correct diagnosis in 25% of patients.[17]

However, it is incorrect to assume that ABPM is 'perfect' in detecting white-coat or masked hypertension. For confirming a diagnosis of white-coat hypertension, it is recommended that ABPM be performed a second time.[6] With use of an incorrect (too small) cuff size, both ABPM and HBPM can underestimate the number of patients with white-coat hypertension and overestimate those with masked hypertension.[31]

Both ABPM and HBPM have been found to be superior to clinic BP measurement for risk prediction, but there have been too few studies to clearly decide between the two

techniques. A systematic review comparing the association of ABPM or HBPM with cardiovascular disease events and mortality in seven published studies showed a tendency for ABPM to be superior to HBPM.[32] A carefully conducted study that used a composite outcome and adjusted for the BP of the other technique found ABPM to be superior.[20]

Both ABPM and HBPM can also be used in the management of hypertension, being likely superior to clinic measurement, but there are few trials that have evaluated the benefits of either technique over office measurements. The use of HBPM has been shown to improve hypertension management compared with clinic BP measurement alone.[33,34] In a randomised controlled trial, using ABPM to manage hypertension led to a reduction in antihypertensive prescriptions and a greater number of patients who ceased medication altogether, but a similar level of BP reduction, compared with conventional BP measurement.[35]

Measured variables from ambulatory blood pressure monitoring

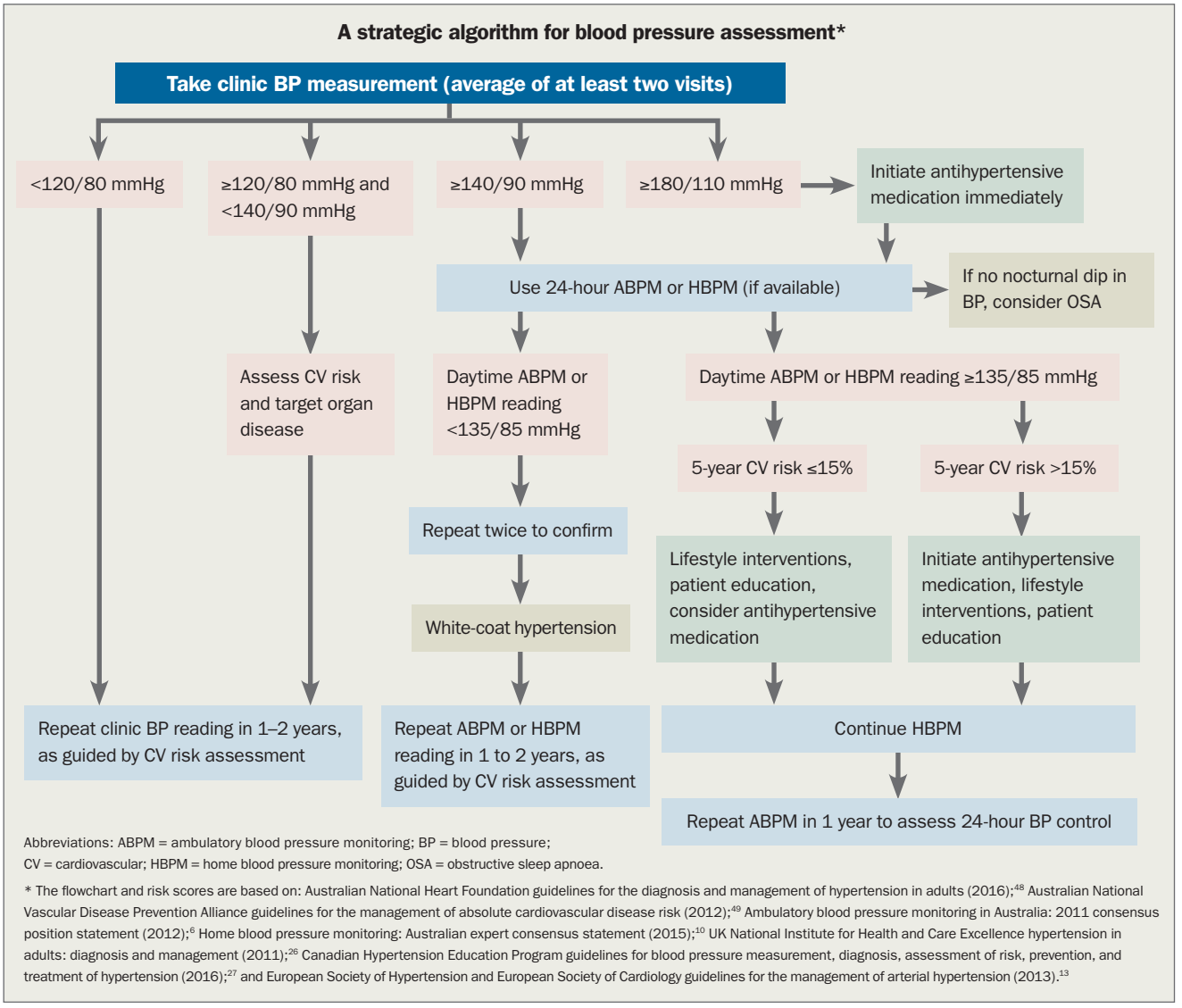
In addition to the standard 24-hour values of systolic and diastolic BP that are reported from an ABPM session, other measures of interest are recorded. If the 'awake' and 'asleep' times are recorded or assessed by accelerometer, these can be used to assess average BP levels during periods of wakefulness and sleep. These are particularly useful for patients with unusual patterns of wakefulness and sleep and may better reflect the correct degree of nocturnal BP dipping than the standard day and night values.

BP load is a useful measure that indicates the proportion of time in which BP readings exceed the hypertension threshold; it is closely related to mean BP level and BP variability.[36] BP load also reflects end-organ damage better than mean ABPM readings.[36] BP variability can be calculated as the standard deviation of the day–night or awake–asleep values. The morning surge in BP has been suggested as an important risk factor contributing to the higher incidence of stroke and cardiovascular events during the morning.[37]

Two other indices that can be derived from ABPM are the smoothness index,which is useful to assess the effectiveness of pharmacological treatment, and the ambulatory arterial stiffness index, which reflects arterial stiffness and therefore possible vascular damage.[38,39]

Patient preference

An important aspect of out-of-office BP measurement is the patient's preference. In general, patients show more confidence in both ABPM and HBPM measurements than in clinic BP measurements. They have a slight preference for ABPM for reliability, but HBPM has been found more likely to help with the decision to take antihypertensive medication.[40] HBPM is the preferred method for comfort and convenience, with an approval rate of 82% compared with 63% for ABPM.[41]



Abbreviations: ABPM = ambulatory blood pressure monitoring; BP = blood pressure; CV = cardiovascular; HBPM = home blood pressure monitoring; OSA = obstructive sleep apnoea.

* The flowchart and risk scores are based on: Australian National Heart Foundation guidelines for the diagnosis and management of hypertension in adults (2016);[48] Australian National Vascular Disease Prevention Alliance guidelines for the management of absolute cardiovascular disease risk (2012);[49] Ambulatory blood pressure monitoring in Australia: 2011 consensus position statement (2012);[6] Home blood pressure monitoring: Australian expert consensus statement (2015);[10] UK National Institute for Health and Care Excellence hypertension in adults: diagnosis and management (2011);[26] Canadian Hypertension Education Program guidelines for blood pressure measurement, diagnosis, assessment of risk, prevention, and treatment of hypertension (2016);[27] and European Society of Hypertension and European Society of Cardiology guidelines for the management of arterial hypertension (2013).[13]

Although a patient's preference should be considered, the greater accuracy and value of nocturnal BP measurements with ABPM must also be taken into consideration. A descriptive study from the Netherlands, which does not have a high uptake of out-of-office technology, was designed to determine the patient's and doctor's real-world experiences. The study reported that the perceived usefulness and ease of use influenced the acceptance of ABPM by both patient and doctor.[42] For patients, acceptance of HBPM was dependent on the practitioner's adoption of the technology, which was in turn affected by the ambiguity and ambivalence in the guidelines.[42] Patients are therefore taking their lead from doctors, who need to be informed about the importance of measuring BP out of the office.

Cost effectiveness

There are costs to patients associated with both methods, as neither HBPM devices nor the ABPM service are reimbursed through Medicare in Australia (except for veterans, for whom ABPM is reimbursed). The more sophisticated HBPM devices, which have memory and in some cases arrhythmia detection, are readily available and incur a one-off cost equivalent to a few months of an antihypertensive prescription. The cost of a single ABPM session is also equivalent to two to three months of a prescription, so there is a clear benefit to patients with white-coat hypertension if treatment can be avoided.

The cost-effectiveness for society is clear, as improved assessment of hypertension and diagnosis of masked hypertension can result in more precise diagnosis of hypertension and cardiovascular risk and reduce the costs associated with strokes and heart attacks.[43-46] This has been shown in the Australian context.[47] Both techniques have been shown to reduce the number of prescriptions and clinic visits required for the management of hypertension.

Recommendations

The evidence to support the use of out-of-office BP measurements for the correct diagnosis and better management of hypertension is overwhelming, and such methods should be an important part of the clinical assessment. There are, however, multiple proposed guidelines with suggestions on how to progress the decision process for patients, which can make implementation more complicated for doctors. Aspects of several different strategies have been combined to produce an algorithm that is intended to be easy to follow (Flowchart).[6,10,13,26,27,48,49]

The recommended strategic algorithm for assessing BP in the management of patients with high BP is based mainly on the Australian ABPM and HBPM consensus statements.[6,10] Initial screening to determine the patient's office BP level should be done using the average reading from at least two visits. For those with clinic BP readings of 180/110 mmHg or more, immediate initiation of antihypertensive medication is highly recommended. Use of ABPM and HBPM, if available, is encouraged for those with clinic BP readings of 140/90 mmHg or more. If white-coat hypertension is detected with ABPM or HBPM then a second assessment should be performed to confirm the diagnosis. Follow up within one to two years is recommended.

When white-coat hypertension is ruled out, lifestyle interventions and patient education should be initiated, with antihypertensive medication initiated or considered depending on the patient's absolute cardiovascular risk and target organ disease. If the HBPM reading is found to be consistent with the daytime ABPM reading then HBPM can be used as part of the management of hypertension. Repeating ABPM once a year is recommended to assess nocturnal BP levels.

Although not shown in the flowchart, ABPM and/or HBPM is also recommended for those with BP readings of less than 140/90 mmHg to identify potential masked hypertension. The prevalence of untreated masked hypertension is reportedly about 9% in the general population,and these patients have a level of cardiac hypertrophy and target organ damage similar to those with sustained hypertension.[50,51] Masked hypertension must be suspected when there is any evidence of target-organ damage in patients presenting with normal or only slightly elevated office BP levels.

Conclusion

Both ABPM and HBPM are valid BP measurement options, but they are not interchangeable. Preference must be given to ABPM as the gold standard. It should be used in conjunction with both HBPM and clinic BP measurements for optimal patient management. **CT**

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A list of references is included in the online version of this article (www.cardiologytoday.com.au).

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