Ambulatory blood pressure monitoring (ABPM) is a vital tool in the diagnosis and management of hypertension. A systematic approach is required to properly interpret an ABPM recording.

The most recent UK guidelines from the National Institute for Health and Care Excellence (NICE) on the clinical management of primary hypertension in adults state that ambulatory blood pressure monitoring (ABPM) should be offered to all patients with a clinic blood pressure (BP) reading of 140/90 mmHg or higher. Although no such recommendation currently exists in Australia, the Ambulatory Blood Pressure Monitoring Working Group (a subcommittee of the National Heart Foundation of Australia National Blood Pressure and Vascular Disease Advisory Committee and the High Blood Pressure Research Council of Australia) has formed the consensus view that ABPM provides ‘considerable added value’ on top of clinic BP toward accurate diagnosis and the provision of optimal care for patients with either suspected or true hypertension. In addition, they have identified a number of patient groups for whom ABPM is indicated (Box).

Unfortunately, ABPM remains underused in Australia. Possible reasons include the cost to patients, the limited availability of ABPM and the knowledge gap for many clinicians about interpreting an ABPM recording versus a clinic BP reading.

**WHY PERFORM AN ABPM?**

The Australian Ambulatory Blood Pressure Monitoring Working Group states that ABPM is indicated for a number of patient groups (Box). However, ABPM should be considered for all patients who are being seen for assessment and management of their BP. The key

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**Key points**

- Ambulatory blood pressure monitoring (ABPM) is a useful tool in diagnosing and managing patients with an elevated clinic blood pressure (BP) reading.
- ABPM assesses a patient’s BP more accurately than clinic measurements and provides additional key information about the patient’s BP profile, including daytime (awake) and night-time (asleep) BP.
- ABPM can identify patients with masked hypertension (hypertension not detected by clinic BP measurements).
- Key results from ABPM must be identified to interpret a recording; these include the number of valid BP measurements, average daytime and night-time BPs, BP load and nocturnal dipping pattern.
reasons for this are the limitations associated with clinic BP measurement. Clinic BP provides only a single snapshot of a patient’s BP and is prone to errors. In particular, it can be influenced by the white-coat effect. In contrast, ABPM can provide a profile of the patient’s BP over 24 hours, and its results have been found to correlate better with cardiovascular outcomes in both the general and hypertensive populations.

**ABPM versus home BP measurement**

An alternative means of obtaining a nonclinic BP is by home BP measurement. This has advantages over ABPM as it is cheaper and less onerous on the patient and can be performed by patients themselves. However, it is essential that a validated device is used. Patients must also be appropriately educated as to how to take readings. In regards to when to take readings, the European Society of Hypertension has suggested that two measurements be taken both in the morning and the evening for at least three to four days.

At present, opinions differ as to whether home BP measurement is as effective as ABPM. A number of studies have found home BP measurement to be as effective as ABPM in identifying prognosis, but other studies have found home BP to be inferior to ABPM. Overall, both home BP measurement and ABPM have roles in the diagnosis and management of hypertension, which may be complementary.

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**Current indications for ambulatory blood pressure monitoring**

- Suspected white-coat effect
- Suspected masked hypertension
- Suspected lack of nocturnal dipping
- Elevated risk of future cardiovascular events
- Continued hypertension despite appropriate treatment
- Known or suspected episodic hypertension

*As suggested by the Ambulatory Blood Pressure Monitoring Working Group. Adapted from Head GA et al. J Hypertens 2012; 30: 253-266.

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**Steps in interpreting an ambulatory blood pressure recording**

1. **Patient undergoes ambulatory blood pressure monitoring (ABPM)**
2. **Is the ABPM satisfactory?**
   - >14 daytime readings and >7 night-time readings, and
   - >70 to 85% of readings are valid
3. **Assess average BP levels compared with ABPM hypertension thresholds; a level exceeding any one of the following is classed as hypertension:**
   - 24-hour average ≥130/80 mmHg
   - Daytime average ≥135/85 mmHg
   - Night-time average ≥120/70 mmHg
4. **Assess BP load (percentage of readings above hypertension threshold)**
   - Ideally, BP load <20%
5. **Assess nocturnal dipping**
   - Nondipper: <10%
   - Normal: 10 to 20%
   - Extreme dipper: >20%

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**How is ABPM performed?**

ABPM must be performed using a validated BP monitor, and a list of these is available from the British Hypertension Society (www.bhsoc.org). Most monitors utilise the oscillometric method of measuring BP, with the cuff usually worn on the patient’s nondominant arm. It is essential to ensure the correct-sized cuff is used, and an initial reading is performed and compared with a measurement obtained from a calibrated sphygmomanometer at the clinic. The patient should be advised to keep their arm still whenever the cuff inflates, and should be provided with an information sheet that explains, for example, how to remove and turn off the device if they are unable to complete the recording.
Readings are usually taken over a 24-hour period, and can be performed up to every 15 minutes when the patient is awake, and up to every 30 minutes when they are asleep. ABPM should be undertaken during a normal ‘working’ day for the patient, and they should keep a diary of the day’s activities, including the time of any medications, exercise and when they went to bed.

**HOW TO INTERPRET AN ABPM**

As ABPM yields multiple BP readings, it can provide the clinician with information beyond simple BP measurement. This includes average BP readings over the time of measurement. It must be remembered that the threshold values for hypertension on ABPM are lower than those for clinic BP readings (see Table 1).

As a significant amount of information is provided, the interpretation of an ABPM record can be difficult and requires a considered approach. A suggested approach to interpretation is shown in the flowchart. A sample ABPM report for Patient X is summarised in Figures 1 and 2 and Table 2.

**Is the ABPM satisfactory?**

The first question that needs to be answered is whether the ABPM has been carried out satisfactorily, which is determined by:

- the number of BP readings during both the daytime and night-time
- the percentage of readings which have been performed successfully.

There is no single international protocol stating how often BP should be measured during an ABPM, with readings being carried out up to every 15 minutes when the patient is awake, and up to every 30 minutes when they are asleep. However, it has been recognised that more than 14 BP measurements are required during the day and more than seven are required at night for the ABPM to be considered satisfactory.

In addition, the percentage of successful readings must be assessed. There is also no international consensus on the minimum percentage of successful readings required for the ABPM to be considered satisfactory. Current guidelines suggest that if more than 70 to 85% of attempts result in a successful reading then the recording should be considered satisfactory. Unsuccessful ('error') readings can result from a movement artefact, systolic BP outside the device’s range, significant variation in the pulse rate and low battery/power.

Figure 2 shows the ABPM readout for Patient X, which can be considered satisfactory. A total of 39 valid BP measurements were obtained with one invalid (error) measurement, giving a success rate of 97.5%. Valid measurements comprised 31 taken during the day (awake) and eight measurements taken at night (asleep).

**TABLE 1. RELATION BETWEEN CLINIC AND AMBULATORY BLOOD PRESSURE THRESHOLDS**

<table>
<thead>
<tr>
<th></th>
<th>Clinic BP (mmHg)</th>
<th>24-hour average</th>
<th>Daytime average</th>
<th>Night-time average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal range</td>
<td>&lt;120/80</td>
<td>&lt;115/75</td>
<td>&lt;120/80</td>
<td>&lt;105/65</td>
</tr>
<tr>
<td>Hypertension threshold</td>
<td>140/90</td>
<td>130/80</td>
<td>135/85</td>
<td>120/70</td>
</tr>
</tbody>
</table>

ABBREVIATION: BP = blood pressure. Adapted from Head et al. J Hypertens 2012; 30: 253-266.
Readings should be interpreted alongside the patient’s diary as exercise results in higher BP readings. Elevated BP readings associated with exercise do not require clinical intervention.

**Average blood pressure**

Secondly, the average BP readings should be assessed by comparison with the ABPM thresholds for hypertension (Box 1). As an ABPM is performed outside the clinic, it can identify patients with white-coat hypertension or masked hypertension. White-coat hypertension is a well-recognised phenomenon where the clinic BP meets the criteria for hypertension, but BP readings obtained either at home or by ABPM are normal.²

On the other hand, masked hypertension is a relatively new diagnosis gaining increasing attention. Patients with masked hypertension are those who have a clinic BP reading below the threshold for hypertension but are found to have hypertension on ABPM or home BP measurement. Patients with an increased likelihood of masked hypertension include those with obstructive sleep apnoea, chronic kidney disease, evidence of target organ damage despite a normal clinic BP reading and those with a family history of hypertension.² Masked hypertension is estimated to affect up to 10% of the general population.¹⁴ Patients can be classified according to the pattern of hypertension found on ABPM, such as morning hypertension, daytime hypertension or night-time hypertension.¹⁵

Although there has been limited clinical research assessing the outcomes of treatment in patients with masked hypertension, there is a strong argument that they should receive antihypertensive therapy.¹⁶ The main problem in treating this group is assessing their response to therapy, which requires further ABPM.

Table 2 summarises the ABPM findings for Patient X. This reveals that the overall and daytime average BP levels did not exceed their respective thresholds for hypertension, but that the nocturnal average systolic BP was above the nocturnal threshold (120 mmHg). This is an example of a patient with masked hypertension, given that the clinic BP would most likely have been normal.

**Blood pressure load**

The patient’s BP load should be assessed next, defined as the percentage of time that the BP readings exceeded the hypertension threshold during the 24 hours (that is, were more than 135/85 mmHg during the day and more than 120/80 mmHg during the night).¹⁷ The BP load is very closely related to the average BP. Ideally, the BP load should be less than 20%. The BP load has been found to better predict end-organ damage than a clinic BP measurement.¹⁸

The BP load is a useful parameter to consider especially in patients with treated hypertension, and if elevated may suggest a need to increase antihypertensive treatment despite a normal average BP on ABPM. For a nonhypertensive patient, the significance of a BP load over 20% is uncertain, but it may indicate a need to ensure basic lifestyle interventions are implemented, with close follow up of BP.
Table 2 shows that the BP load for Patient X is more than 20%, given that the proportion of BP readings above the hypertension threshold was 42% for daytime systolic BP, 63% for night-time systolic BP and 38% for night-time diastolic BP. The BP load was less than 20% only for daytime diastolic BP (19%).

**Dipper or nondipper?**
There is normally a diurnal variation in BP, with BP being lower at night than during the day, known as ‘dipping’. The ABPM report should be assessed for nocturnal nondipping, defined as a fall of less than 10% in either the average systolic BP or the average diastolic BP at night compared with their respective daytime averages.²

Suggested causes of nondipping are both intrinsic and extrinsic. They include hormonal and metabolic factors such as increased sympathetic activation of the autonomic nervous system and hypothyroidism, various disease states...
including diabetes mellitus, obesity, sleep apnoea and chronic kidney disease, and factors such as ageing and smoking.\textsuperscript{19}

Nondipping may indicate the presence of end-organ damage and is associated with a higher risk of future cardiovascular events.\textsuperscript{20,21} This finding has led to research that focuses on tailoring antihypertensive treatment so as to mirror the normal circadian BP pattern.\textsuperscript{22,23} Current results suggest that there may be some benefit from nocturnal dosing of therapy in an attempt to achieve the normal diurnal pattern of BP in hypertensive patients. In contrast, some patients show extreme dipping – more than 20%.\textsuperscript{2} The clinical significance of extreme dipping is currently not well understood.

Table 2 shows that Patient X is a non-dipper as his average systolic BP fell less than 10% (6.9%) during the night.

**Special considerations**
In certain patient groups, different BP thresholds for treatment may need to be considered for ABPM. These groups include children and adolescents, pregnant women and patients receiving haemodialysis or peritoneal dialysis.

**CONCLUSION**
ABPM provides clinicians with important information about the patient’s BP profile, which can be used to guide future management. It should be considered in all patients with an elevated or borderline clinic BP reading.

**REFERENCES**
A list of references is included in the website version (www.medicinetoday.com.au) and the iPad app version of this article.

**COMPETING INTERESTS:** None.
Ambulatory blood pressure monitoring
Beyond the simple BP

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REFERENCES