The clinical value of ambulatory blood pressure monitoring

1996 marked the centenary of the invention of the mercury sphygomanometer by Scipione Rive-Rivocci and a symposium in his honour was held at a recent satellite meeting to the International Society of Hypertension biannual meeting in Glasgow. It is perhaps, therefore, a good time to take stock of the current status of blood pressure measurement, in particular the increasing interest in the value of ambulatory blood pressure monitoring.

The increasing availability and improved reliability of ambulatory devices has lead to a dramatic increase in their use over recent years. This article reviews the implications of ambulatory blood pressure monitoring for our knowledge of the pathogenesis of hypertension, its clinical usefulness, and the evidence for its use in the routine management of hypertensive patients.

Development of ambulatory blood pressure monitoring devices

The first non-invasive blood pressure monitor, the Remler M2000, was developed in 1962 and research using this device subsequently revealed that ambulatory blood pressure monitoring was a more sensitive predictor of morbidity and mortality than casual office blood pressure readings although there was some concern regarding the accuracy of the machine. Since this early model there have been significant technological developments and there are now over 15 commercially available automated non-invasive systems.

The use of ambulatory monitoring has demonstrated the enormous variation in blood pressure and provided data for the characterisation of both nocturnal blood pressure and the diurnal pressure pattern. Ambulatory monitoring has also made it possible to determine the efficacy and duration of action of antihypertensive drugs, often with a relatively small numbers of patients. However, a number of technical and clinical aspects remain unresolved.

Reference values

The diagnosis of an abnormality requires the definition of normality and one problem associated with the use of ambulatory blood pressure monitoring in clinical practice has been the lack of internationally accepted reference values. Population studies have been used to define normal ambulatory blood pressure ranges, according to age and sex, and it is now possible to plot 24 hour blood pressures for each patient and determine if they fall within these accepted bands. The disadvantage of this method has been that many of the earlier published data were not obtained from population based samples. These “normal” populations were therefore dependent on the criteria for sample inclusion and exclusion. In addition, selection has largely been based on conventional clinic blood pressures, thereby limiting the validity of this method.

An alternative approach has been to identify the upper limit of ambulatory blood pressure associated with an acceptably low level of cardiovascular risk. However, the recently published PAMELA study, obtaining data from a large unbiased population sample, demonstrated that 24 hour and daytime average blood pressures were much lower than clinic blood pressures. Similar findings were obtained in the Allied Irish Bank studies.

There are more than 30 cross sectional studies that have linked ambulatory blood pressure to target organ damage using the parameters of left ventricular hypertrophy, microalbuminuria, retinal hypertensive changes, and cerebrovascular disease. These studies have revealed ambulatory blood pressure to be a more sensitive predictor of target organ damage than single casual office measurements, and it has been assumed that these surrogate end points of target organ involvement can be extrapolated to the ultimate end points of cardiac or cerebrovascular death and morbidity. This is certainly a logical and rational approach, although there can be no substitute for well conducted prospective interventional studies of ambulatory blood pressure and prognosis to resolve this point.

Prognosis and ambulatory monitoring

Since the early studies, which showed that the risk of a cardiovascular event is more closely related to ambulatory blood pressure than casual office measurement, there have been few studies to confirm the relation. Indeed some of the studies that appeared to correlate ambulatory blood pressure with cardiovascular risk have been criticised in terms of trial design and analytical methodology. In fact, it must come as no surprise that the daytime average blood pressure based on 24 half-hourly measurements with an accurate apparatus will be more predictive than one or two single casual blood pressure readings obtained in the somewhat intimidating environment of a university hospital. There is reliable evidence that junior doctors measure blood pressures badly, and the retesting of measurement techniques by senior clinicians would provide entertaining results.

The superiority of ambulatory monitoring over hospital based blood pressure readings in predicting mortality and morbidity may well be less pronounced if well trained nurses were to take a more prominent role. In two studies the hospital based nurse blood pressure readings more closely resembled the daytime average ambulatory measurements than the readings by the doctors.

There is longitudinal evidence that the cardiovascular complications of hypertension may also depend on the degree of 24 hour blood pressure variability. In addition, the results of a recently published long term study do suggest that ambulatory blood pressure stratifies cardiovascular risk in essential hypertension, independently of clinic blood pressure and other traditional risk markers. This study also examined the significance of a blunted or absent reduction in nocturnal blood pressure (non-dipper status) and a raised pressor response in the clinic environment (white coat hypertension).

White coat hypertension

The difference between single casual office blood pressure readings and the daytime average blood pressure obtained by ambulatory blood pressure monitoring has been termed the “white coat effect”, and this effect varies immensely between individuals. A more worrying concept, however, is that of “white coat hypertension”, which is a diagnosis based on arbitrary dividing lines. This diagnosis has been attributed to as many as 20% of patients who would otherwise be classified as being hypertensive.
The clinical significance of white coat hypertension has yet to be established. Cross sectional studies have provided conflicting results. Some echocardiographic studies of left ventricular size have reported that people with white coat hypertension have similar indices to normotensive people, and one follow up study has even suggested that they have a similar prognosis. In contrast, some studies have reported that left ventricular dimensions in white coat hypertension are somewhere between those of normotension and sustained hypertension. Furthermore, patients with white coat hypertension differ in metabolic, neuroendocrine, and cardiac findings from normal control subjects and have greater blood pressure variability.

A recent study from Glasgow reported that even if white coat hypertension is associated with similar left ventricular dimensions to normotension, left ventricular function, as assessed by E/A ratios and isovolumic relaxation time, more closely resembles that of hypertension, even after adjustment for the height of the blood pressure. White coat hypertension may therefore be a true variant of hypertension and is probably not an innocent condition, but may represent an early phase of hypertension. Another follow up study of 81 people with white coat hypertension demonstrated that 75% developed sustained hypertension over a follow up period of six years.

The main cause for concern is that patients who have been labelled by ambulatory blood pressure monitoring enthusiasts as having white coat hypertension may be inappropriately reassured and thus drop out of follow up. We suggest that the term white coat hypertension should be dropped and replaced by the classification of patients having a large, medium or small white coat effect. In some patients with a large white coat effect, the daytime average blood pressure may still be raised, although much lower than in the clinic, and treatment will still be needed.

**Dippers and non-dippers**

The significance of average night time blood pressure readings remains equally uncertain. Stroke, silent cerebrovascular disease, and left ventricular hypertrophy are more common in patients who do not demonstrate the normal nocturnal fall in blood pressure, and this has led to the assumption that non-dipper status is an independent predictor of cardiovascular morbidity and mortality. There are a number of potential problems that may complicate this interpretation. Vascular disease itself could impair nocturnal blood pressure fall through impairment of cardiovasculare reflexes. It remains uncertain whether this non-dipper status genuinely reflects a greater daily blood pressure load or whether it merely means that the patient did not sleep as soundly, having been disturbed by the inflation of the blood pressure cuff.

The results of a number of large scale studies of ambulatory blood pressure and prognosis are awaited. These include the European study OVA, the study on ambulatory blood pressure and treatment of hypertension (APHT), the SAMPLE study and the ABP arm of the European Working Party on High Blood Pressure Syst-Eur study.

**Accuracy and interpretation of ambulatory blood pressure monitoring**

The British Hypertension Society Working Party on blood pressure measurement has published comprehensive guidelines relating to the evaluation and standardisation of ambulatory blood pressure monitors in terms of accuracy, precision, and reproducibility. This has effectively limited equipment inaccuracy in immobile subjects, although vigorous activity may alter blood pressure readings.

An activity diary may be valuable when interpreting blood pressure measurements at different times of the day. The devices that meet the standards set by the British Hypertension Society and Association for the Advancement in Medical Instrumentation are included in table 1.

An additional concern relates to data management and it may be that different techniques are appropriate for different purposes. The simplest and most widely applied method uses the arithmetic mean and median blood pressures for wake, sleep, and 24 hours. An alternative approach is to use a combination of the average daytime reading and blood pressure load (percentage of recordings above 140 mm Hg systolic and below 90 mm Hg diastolic). The validity of this method is limited as it depends on an arbitrary threshold and there is no clear evidence of an advantage with more complex statistical methods of analysis.

Another problem is that ambulatory blood pressure monitoring systems that rely on the auscultatory method of measuring pressure (a microphone over the brachial artery) require ECG gating, with the attendant added complexity. Oscillometric systems like the Spacelabs 90207 do, however, provide accurate readings.

In practical terms it is important to advise the patient that occasional discomfort may be experienced in the arm, particularly when blood pressure is high. Constrictive clothing may displace the cuff or interfere with cuff placement and should be avoided. Some advocates of the auscultatory method recommend taping the cuff to the arm of the patient, although this may be uncomfortable.

**Conclusion**

Patients with evidence of target organ damage, previous cardiovascular events, high office blood pressure, and older age are at high risk of developing vascular complications of hypertension, and are therefore likely to require antihypertensive treatment, irrespective of the 24 hour blood pressure profile.

Ambulatory monitoring has a role in the assessment of some mild hypertensive patients who have absolutely no evidence of end organ damage and who appear agitated or distressed, particularly at hospital attendance. It is also of value in hypertension that appears to be drug resistant, and in those without evidence of cardiovascular damage as these patients may have a white coat effect. In addition, 24 hour monitoring may be of value in the assessment of antihypertensive treatment, particularly with symptoms suggestive of hypotension.

The true significance of white coat hypertension and the association between ambulatory blood pressure and prognosis will become clearer when the results of prospective interventional studies become available. In the meantime 24 hour ambulatory blood pressure monitoring does not, in the majority of patients, offer any clear advantage over careful conventional office blood pressure measurements.

---

**Table 1. Ambulatory blood pressure monitoring devices that have fulfilled British Hypertension Society* and Association for the Advancement in Medical Instrumentation†**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Device</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diestronic</td>
<td>CH-Druck</td>
<td>Auscultatory</td>
</tr>
<tr>
<td>Medical Systems</td>
<td>Profilomat</td>
<td>Auscultatory</td>
</tr>
<tr>
<td>IDT</td>
<td>Nisse DS-240</td>
<td>Auscultatory</td>
</tr>
<tr>
<td>Welch Allyn</td>
<td>Quiet Track</td>
<td>Oscillometric</td>
</tr>
<tr>
<td>SpaceLabs</td>
<td>SpaceLabs 90202</td>
<td>Auscultatory</td>
</tr>
<tr>
<td>A&amp;D Company</td>
<td>SpaceLabs 90207</td>
<td>Oscillometric</td>
</tr>
<tr>
<td>PMS Instruments</td>
<td>TM-2420 Model 6</td>
<td>Oscillometric</td>
</tr>
<tr>
<td></td>
<td>TM-2420 Model 7</td>
<td>Auscultatory</td>
</tr>
<tr>
<td></td>
<td>TM-2421</td>
<td>Oscillometric</td>
</tr>
</tbody>
</table>

Reproduced with permission of BMJ Publishing Group. Devices must achieve at least grade B/B; *mean difference < 5 mm Hg (SD < 8 mm Hg) (assessment took place in January 1995).

*The manufacturers must achieve at least grade B/B; †mean difference < 5 mm Hg (SD < 8 mm Hg) (assessment took place in January 1995).*
obtained in a quiet non-stressful environment by a well trained doctor or nurse.

C R GIBBS
S MURRAY
D G BEEVERS

Department of Medicine,
City Hospital NHS Trust,
Dudley Road,
Birmingham, B18 7QH, UK

The clinical value of ambulatory blood pressure monitoring

C R GIBBS, S MURRAY and D G BEEVERS

Heart 1998 79: 115-117
doi: 10.1136/hrt.79.2.115

Updated information and services can be found at:
http://heart.bmj.com/content/79/2/115

These include:

References
This article cites 22 articles, 9 of which you can access for free at:
http://heart.bmj.com/content/79/2/115#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections
Articles on similar topics can be found in the following collections:

Hypertension (3006)
Epidemiology (3752)
Drugs: cardiovascular system (8842)

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/