Home Blood Pressure Measurements Will Not Replace 24-Hour Ambulatory Blood Pressure Monitoring

Paolo Verdecchia, Fabio Angeli, Giovanni Mazzotta, Giorgio Gentile, Gianpaolo Reboldi

According to Heródotos, during the month of August in the year 480 BC, a few hundred elite soldiers from Sparta, led by their king Leonida, fiercely fought at the pass of Thermopylae against an overwhelming Persian army led by Serse. Almost all of the Spartans died. The huge discrepancy between the 2 armies at the Thermopylae pass might resemble in some way the discrepancy in the number of outcome-based studies with home blood pressure (BP) and 24-hour ambulatory BP (ABP; Table 1).

It is out of the question that home BP is a highly valuable clinical tool, and its use is constantly growing in United States and elsewhere. However, it is also out of the question that, compared with home BP, ABP received over the past 2 or 3 decades a greater bulk of data supporting its use to refine risk stratification and, in general, the management of the hypertensive patient.

Clinical Considerations

Although both home BP and ABP provide a better prediction of organ damage and the risk of cardiovascular complications when compared with office BP, each of the 2 techniques has inherent advantages and disadvantages that make them complementary more than alternative.

Table 2, partially modified by a recent position paper of the American Society of Hypertension, synthesizes the main features of both. The present review holds the position that 24-hour ABP should not be replaced by home BP because of its unequivocal superiority under several diagnostic and prognostic aspects. Home BP and 24-hour ABP should possibly be considered as complementary techniques, to be used with the precise aim of exploiting the best that each technique can provide.

Outcome-Based Studies With 24-Hour ABP and Home BP

After the first landmark observations by Perloff et al., many longitudinal, event-based studies demonstrated an independent association between ABP or home BP and the risk of death or cardiovascular disease. Table 1 shows a list of such studies, obtained through an electronic search of the literature using the terms “ambulatory BP,” “home BP,” and “prognosis.”

The 2 main features shared by these studies are the qualifying ABP or home BP session carried out at entry and the subsequent period of follow-up, usually lasting some years, during which many incident serious events were recorded. Treatment was usually adjusted to the individual subject without constrains, although a minority of data emerged from the setting of intervention trials.

To limit the potential overlap between different studies, our list was restricted to studies carried out by independent groups. Because each group generally published several analyses of their database, we tried to include in Table 1 only the studies published first or the largest contribution provided by each group. Given the fact that such choice is partly subjective, we apologize for any possible inaccuracy.

Overall, although the experimental procedures and the statistical analysis (in particular, the adjustment for potential confounders of the prognostic effect of ABP, eg, age, diabetes mellitus, smoking, and hypercholesterolemia) differed across the studies, the common denominator of these studies is that ABP and home BP generally improved cardiovascular risk stratification.

Prognostic Value of 24-Hour ABP and Home BP: Similarities and Differences

Different Clinical Settings

The prognostic value of ABP has been examined in a large variety of settings, including the general population.

The opinions expressed in this editorial are not necessarily those of the editors or of the American Heart Association.

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subjects with traditional (ie, based on office BP) diagnosis of hypertension,4,5,11,12,16,17,20,24 elderly subjects,19,25 and specific conditions, eg, diabetes mellitus,15 cerebrovascular disease,10,14 and resistant hypertension.9 Such a variety of settings looks reassuring in terms of possible areas of application of 24-hour ABP monitoring. In contrast, 1 prognostic study with home BP has been conducted in patients with renal failure,26 4 studies are from the general population,21,22,27,28 and only 1 study has been conducted in subjects with clinical diagnosis of hypertension29 (ie, the most likely set to which the results of these studies should be applied.

Interference With Antihypertensive Treatment

Some of the longitudinal studies with ABP monitoring have been conducted in subjects not receiving antihypertensive drugs at the time of their ABP monitoring session.1,2,11,12,16,17,20,24 Other studies have been conducted only in treated subjects 6,9,10,18 and others in a mixture of both.7,8,13,14,15,21–23,25

Table 1. Longitudinal Event-Based Studies From Independent Groups Addressing the Prognostic Value of Ambulatory and Home BPs

<table>
<thead>
<tr>
<th>First Author</th>
<th>Journal</th>
<th>Year of Publication</th>
<th>Subjects, n</th>
<th>Follow-Up, y</th>
<th>Total Events</th>
<th>Fatal Events</th>
<th>Clinical Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perloff4</td>
<td>JAMA</td>
<td>1983</td>
<td>1076</td>
<td>5</td>
<td>153</td>
<td>75</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Verdecchia5</td>
<td>Hypertension</td>
<td>1994</td>
<td>1187</td>
<td>3.2</td>
<td>89</td>
<td>21</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Zweiker6</td>
<td>Acta Med Austr</td>
<td>1994</td>
<td>116</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>Hypertension (T)</td>
</tr>
<tr>
<td>Ohkubo7</td>
<td>J Hypertens</td>
<td>1997</td>
<td>1542</td>
<td>5.1</td>
<td>93</td>
<td>93</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Nakano8</td>
<td>Diabetes</td>
<td>1998</td>
<td>325</td>
<td>4</td>
<td>76</td>
<td>31</td>
<td>Type 2 diabetes (B)</td>
</tr>
<tr>
<td>Redon9</td>
<td>Hypertension</td>
<td>1998</td>
<td>86</td>
<td>4</td>
<td>21</td>
<td>nr</td>
<td>Hypertension (T)</td>
</tr>
<tr>
<td>Yamamoto10</td>
<td>Stroke</td>
<td>1998</td>
<td>105</td>
<td>3.2</td>
<td>15</td>
<td>3</td>
<td>Previous stroke (T)</td>
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<tr>
<td>Khattar11</td>
<td>Circulation</td>
<td>1998</td>
<td>479</td>
<td>9.1</td>
<td>98</td>
<td>38</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Staessen12</td>
<td>JAMA</td>
<td>1999</td>
<td>808</td>
<td>4.4</td>
<td>98</td>
<td>68</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Suzuki13</td>
<td>Hypertens Res</td>
<td>2000</td>
<td>310</td>
<td>4.3</td>
<td>57</td>
<td>12</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Sander14</td>
<td>Circulation</td>
<td>2000</td>
<td>286</td>
<td>3.3</td>
<td>36</td>
<td>14</td>
<td>Suspected cerebral ischemia (B)</td>
</tr>
<tr>
<td>Sturrock15</td>
<td>Diabet Med</td>
<td>2000</td>
<td>75</td>
<td>4</td>
<td>25</td>
<td>13</td>
<td>Type 1 and 2 diabetes (B)</td>
</tr>
<tr>
<td>Kario16</td>
<td>JACC</td>
<td>2001</td>
<td>958</td>
<td>3.5</td>
<td>62</td>
<td>14</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Gustavsen17</td>
<td>J Hum Hypertens</td>
<td>2003</td>
<td>566</td>
<td>10</td>
<td>80</td>
<td>16</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Clement18</td>
<td>N Engl J Med</td>
<td>2003</td>
<td>1963</td>
<td>5</td>
<td>157</td>
<td>78</td>
<td>Hypertension (T)</td>
</tr>
<tr>
<td>Bjorklund19</td>
<td>Circulation</td>
<td>2003</td>
<td>578</td>
<td>8.4</td>
<td>72</td>
<td>14</td>
<td>Elderly men (U)</td>
</tr>
<tr>
<td>Pierdomenico20</td>
<td>Am J Hypertens</td>
<td>2004</td>
<td>1279</td>
<td>4.5</td>
<td>54</td>
<td>nr</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Fagard21</td>
<td>J Hum Hypertens</td>
<td>2005</td>
<td>391</td>
<td>10.9</td>
<td>86</td>
<td>55</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Sega22</td>
<td>Circulation</td>
<td>2005</td>
<td>2051</td>
<td>10.9</td>
<td>nr</td>
<td>186</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Hansen23</td>
<td>Hypertension</td>
<td>2005</td>
<td>1700</td>
<td>9.5</td>
<td>174</td>
<td>63</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Dolan24</td>
<td>Hypertension</td>
<td>2005</td>
<td>5292</td>
<td>7.9</td>
<td>nr</td>
<td>646</td>
<td>Hypertension (U)</td>
</tr>
<tr>
<td>Ingelsson25</td>
<td>JAMA</td>
<td>2006</td>
<td>951</td>
<td>9.1</td>
<td>70</td>
<td>nr</td>
<td>Adult men cohort (B)</td>
</tr>
</tbody>
</table>

Home BP

<table>
<thead>
<tr>
<th>First Author</th>
<th>Journal</th>
<th>Year of Publication</th>
<th>Subjects, n</th>
<th>Follow-Up, y</th>
<th>Total Events</th>
<th>Fatal Events</th>
<th>Clinical Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agarwal26</td>
<td>Kidney Int</td>
<td>2006</td>
<td>257</td>
<td>3.5</td>
<td>75</td>
<td>52</td>
<td>Chronic kidney disease (B)</td>
</tr>
<tr>
<td>Ohkubo27</td>
<td>J Hypertens</td>
<td>1998</td>
<td>1789</td>
<td>6.6</td>
<td>nr</td>
<td>52</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Sega22</td>
<td>Circulation</td>
<td>2005</td>
<td>2051</td>
<td>10.9</td>
<td>nr</td>
<td>186</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Stergiou28</td>
<td>J Hypertens</td>
<td>2007</td>
<td>662</td>
<td>8.2</td>
<td>67</td>
<td>78</td>
<td>Population (B)</td>
</tr>
<tr>
<td>Bobrie29</td>
<td>JAMA</td>
<td>2004</td>
<td>4938</td>
<td>3.2</td>
<td>324</td>
<td>205</td>
<td>Hypertension (T)</td>
</tr>
<tr>
<td>Fagard21</td>
<td>J Hum Hypertens</td>
<td>2005</td>
<td>391</td>
<td>10.9</td>
<td>86</td>
<td>55</td>
<td>Population (B)</td>
</tr>
</tbody>
</table>

U indicates untreated; T, treated; B, both treated and untreated; nr, not reported.

Table 2. Comparison of Home and ABP

<table>
<thead>
<tr>
<th>Feature</th>
<th>Home BP</th>
<th>ABP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prognostic value (prediction of events)</td>
<td>++ + + + +</td>
<td>+ + + + + + +</td>
</tr>
<tr>
<td>Detection of WCH</td>
<td>+ +</td>
<td>+ + + +</td>
</tr>
<tr>
<td>Detection of MH</td>
<td>+ +</td>
<td>+ + + +</td>
</tr>
<tr>
<td>Detection of day-night BP changes</td>
<td>− + + +</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>Detection of early morning rise in BP</td>
<td>− + + + +</td>
<td>+ + + + + +</td>
</tr>
<tr>
<td>Detection of diurnal or nocturnal BP variability</td>
<td>− + + + +</td>
<td>+ + + + + + +</td>
</tr>
<tr>
<td>Long-term use (evaluation of therapy)</td>
<td>+ + + +</td>
<td>+ + + +</td>
</tr>
<tr>
<td>Reimbursement</td>
<td>+ +</td>
<td>+ +</td>
</tr>
<tr>
<td>Patient’s acceptance</td>
<td>+ +</td>
<td>+ + + +</td>
</tr>
<tr>
<td>Patient’s involvement</td>
<td>+ +</td>
<td>+ +</td>
</tr>
<tr>
<td>Cost</td>
<td>+ +</td>
<td>+ + + +</td>
</tr>
</tbody>
</table>

Modified from References 1 and 3.

Such a variety of settings looks reassuring in terms of possible areas of application of 24-hour ABP monitoring. In contrast, 1 prognostic study with home BP has been conducted in patients with renal failure,26 4 studies are from the general population,21,22,27,28 and only 1 study has been conducted in subjects with clinical diagnosis of hypertension29 (ie, the most likely set to which the results of these studies should be applied.

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The issue of antihypertensive treatment at the time of ABP monitoring is clinically relevant because drug treatment can affect the 24-hour ABP profile and, consequently, the interpretation of results. The usual statistical practice of “adjust-
ing” for concomitant treatments in the assessment of the prognostic value of ABP is valuable, although it may not fully remove the objection by skeptical clinicians of whether results are equally applicable to treated and untreated subjects.3

Just to make an example, it has been suggested that diuretics30 and sodium restriction31 can restore the circadian rhythm of BP with shifting from a nondipper to a dipper status. To which subjects, therefore, should we apply the results of studies addressing the prognostic significance of the day-night BP rhythm when part of the population is receiving diuretics?

As shown in Table 1, ≥9 studies with ABP monitoring have been conducted in hypertensive subjects who were not under treatment with BP-lowering drugs at the time of ABP monitoring. Given the large sample size of these studies, results support the important role of ABP monitoring to improve risk stratification in subjects who are not being pharmacologically treated for hypertension at the time of ABP monitoring.

Because the prognostic value of ABP has also been investigated in studies carried out in treated subjects or in a mixture of treated and untreated subjects (see above), many experts suggest that its use is adequately supported also in subjects who are being treated at the time of monitoring. By comparison, none of the studies with home BP have been conducted in untreated subjects at the time of qualifying home BP measurements. One study has been conducted in treated subjects39 and the other studies in a mixed population of treated and untreated subjects.21,22,26–28

Overall, these results point toward a preferential indication for 24-hour ABP measurement (ABPM) in the initial evaluation of untreated subjects and for home BP measurements in the long-term assessment of BP during follow-up in treated subjects.

Arbitrary Categories of Patients

Several investigators tried to define clinical categories based on arbitrary thresholds of ABP. Examples are “white-coat hypertension” (WCH)32 and “dippers/nondippers.”33 Although such categories are potentially useful in the clinical practice,44 their ultimate impact on the therapeutic management of hypertensive patients is still debated.

White-Coat Hypertension

WCH is generally defined as a persistently high office BP with a normal BP outside the office.32 The original definition of WCH applied to untreated subjects32 in the hypothesis that the alerting reaction to a visit might cause a transient rise in BP,35 with potential misclassification of a normotensive subject as a hypertensive patient. In our opinion, caution should be exerted in applying the above definition to treated subjects because of the possibility that drug treatment may elicit a different drop in office and out-of-office BP attributable to various reasons, including time of administration with respect to the visit and duration of action of drugs. Treated hypertensive subjects with out-of-office BP normalized by drugs and with a high office BP do appear to be basically different from untreated subjects with BP rise attributable to an isolated alerting reaction to the visit who are otherwise normal in their BP during the rest of the day.

Indeed, several available studies on the prognostic effect of WCH have been conducted in untreated subjects at the time of ABP monitoring.5,11,16,20 In one of these studies, we showed for the first time that cardiovascular morbidity was lower in WCH than in ambulatory hypertension and was not dissimilar between WCH and clinical normotension.3 These data have also been confirmed in a mixed population of treated and untreated subjects.36

Two important caveats for a correct interpretation of the prognostic significance of WCH should be mentioned. The first regards the definition of WCH. WCH should be defined by low (“restrictive”) values of ABP to limit inclusion of subjects with elevated BP (and, hence, potentially high risk) under the definition of WCH. Such a definition would limit the prevalence of WCH but with the advantage of selecting a reasonably low-risk population. Indeed, a study from our group showed that a daytime ABP <130 mm Hg systolic and 80 mm Hg diastolic may be defined as optimal values to identify WCH subjects whose risk can be considered low and not dissimilar from clinically normotensive subjects.37 Higher values of daytime BP are associated with a cardiovascular risk not dissimilar from subjects with sustained hypertension.37 The Pressioni Arteriose Monitorate e Loro Associazioni Study, carried out in the general population, suggested similar reference limits of daytime ABP (129 to 132 mm Hg systolic and 80 to 85 mm Hg diastolic in men and 125 to 129 mm Hg systolic and 80 to 82 mm Hg in women).38 Another caveat with regard to the duration of follow-up, prognosis of WCH seems more benign in a short-term than in a long-term follow-up.39 Although this finding has not been confirmed,40 it could reflect an inherently higher risk of subjects with WCH to develop sustained hypertension in the long run.41

Two prospective studies on WCH carried out with home BP provided conflicting results. Prognosis of WCH was benign (ie, not dissimilar from subjects with normal values for both office and home BPs) in one study conducted in 4939 subjects29 but not in another study conducted in 1997.28 However, the duration of follow-up was longer in the latter study, suggesting that the outcome of subjects with WCH might worsen in the long term.

Overall, these data suggest a strong case for 24-hour ABP monitoring in those subjects, either treated or untreated, with persistently normal home BP and high BP in the office or clinic.

BP Changes From Day to Night

Another area in which 24-hour ABP appears superior to office BP regards the detection of the BP changes from day to night. Landmark studies with intra-arterial BP monitoring showed a clear BP reduction from day to night by ≈20%.42–44 The “dippers/nondippers” classification was first introduced by O’Brien et al53 and Pickering.45 Nondippers are generally defined by a reduction in BP by less than a given percentage from day to night, whereas the subjects not falling under this definition are classified as dippers. The threshold values for classification ranged from 10% to 10/5 mm Hg, up to 0% (ie, no reduction in BP from day to night or a higher BP during

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night than during day). Approximately 22% to 35% of uncomplicated hypertensive subjects can be defined as non-dippers\cite{46,47} and the remaining as dippers. In a minority of subjects ranging from 1% to 3\%\textsuperscript{41-48} to 7\%\textsuperscript{49} nighttime BP is actually higher than daytime BP (so-called “reverse dippers”).

Several studies showed that left ventricular hypertrophy and other organ lesions are more advanced in nondippers than in dippers. There is also evidence from longitudinal studies that a blunted, abolished, or even reversed BP drop from day to night is associated with an increase in the risk of serious cardiovascular complications.\textsuperscript{5,6,46,48-51} Studies that compared to night is associated with an increase in the risk of serious cardiovascular complications.\textsuperscript{5,6,46,48-51} Studies that compared the prognostic value of daytime BP with that of nighttime BP inevitably found the superiority of the latter for predicting prognosis.\textsuperscript{22,23} Daytime BP does not add prognostic precision to information provided by nighttime BP.\textsuperscript{51}

When interpreting nighttime BP, care should be used to obtain information for the patient with regard to the perceived quality and quantity of sleep during BP monitoring. If sleep is perceived as “poor” during overnight BP monitoring (duration of sleep <2 hours less than usual), nighttime BP rises, and its prognostic significance appears to be no longer reliable.\textsuperscript{52}

An objective consideration is that 24-hour ABP monitoring is the only reasonable and established way to measure nighttime BP and the day-night BP changes. Indeed, some modern instruments for home BP measurements could be set to take some occasional BP measurements even during the night,\textsuperscript{53} but their clinical use to refine organ damage prediction and risk stratification should be further investigated.

**BP Variability**

Apart from the seasonal changes, the day-night changes, and the tighter BP changes that occur during respiration, BP may vary in the short term (usually minutes) because of random fluctuations possibly attributed to the effect of a variety of stressors (mental and physical stress, temperature, posture, etc). An enhanced short-term (also known as “random”) BP variability has been associated with target-organ damage in hypertensive patients.\textsuperscript{54} In a study, we classified hypertensive subjects as at low- or high-BP variability according to their SD of daytime and nighttime systolic BP below or above the median. At any given level of 24-hour BP, left ventricular mass at echocardiography did not differ between the groups.\textsuperscript{55} In a recent study, after adjustment for several confounders, a high variability (SD above mean) in systolic BP during the night, but not during the day, was associated with a 51\% higher risk of cardiac events ($P=0.024$) but not of cerebrovascular events. The relations of daytime BP variability with cardiac events and that of daytime and nighttime BP variability with cerebrovascular events were not significant in a multivariate analysis.\textsuperscript{56} Again, 24-hour ABP is clearly superior to home BP for the assessment of BP variability because of the higher number of BP measurements scattered over a longer period of time, which may include periods of stress, rest, work, and so on, with a consequently more reliable estimate of random BP variability.

**Masked Hypertension**

A consistent proportion (10\% to 30\%)\textsuperscript{57} of individuals with normal BP in the clinic actually have elevated levels out of the office. This condition is labeled as “masked hypertension” (MH) or “isolated ambulatory hypertension.” In a population-based study of elderly men who underwent 24-hour ABP monitoring in the absence of treatment, MH was associated with a bad outcome.\textsuperscript{19} After adjustment for serum cholesterol, smoking, and diabetes mellitus, sustained hypertension (hazard ratio: 2.94; 95\% CI: 1.49 to 5.82) and MH (hazard ratio: 2.77; 95\% confidence interval: 1.15 to 6.68) were independent predictors of cardiovascular morbidity when compared with normotensive subjects.\textsuperscript{19} Other studies with 24-hour ABP monitoring\textsuperscript{36,58} and home BP\textsuperscript{28,29,35,59} confirmed the excess risk of events in subjects with MH as compared with subjects with normal values of office and out-of-office BP.

From the data above, it appears that 24-hour ABP and home BP are both suitable to detect MH. However, not being able to monitor BP over the entire 24 hours, home BP could miss a proportion subjects with true MH, eg, those with high nighttime BP. Furthermore, antihypertensive treatment might complicate the interpretation of MH to a similar extent as it happens for WCH, because a normal BP in the office with elevated BP during the rest of the day could reflect a “peak” effect of treatment possibly taken shortly before the visit that is ineffective or scarcely effective for the rest of the day. Despite these caveats, it is generally accepted that subjects with MH should be managed aggressively.\textsuperscript{1}

**How Should We Interpret Results of 24-Hour ABP Monitoring?**

The combined use of home BP and ABP to guide clinical decisions had been suggested previously by an American Society of Hypertension working group,\textsuperscript{60} by White,\textsuperscript{61} and by Myers.\textsuperscript{62} Following this line of thinking, home BP might be considered a cheap and valuable first-line procedure. In case of increased BP values (>135/85 mm Hg), treatment is suggested on the basis of the an allegedly increased cardiovascular risk. However, it has been noted\textsuperscript{63} that such a recommendation is not fully evidence based, because home BP has never been tested in outcome-based studies in subjects who were untreated at the time of qualifying home BP recording. There is ample evidence that the prognostic value of pretreatment (“achieved”) BP is less powerful than that of in-treatment (“achieved”) BP.\textsuperscript{64-66} Therefore, the recommendation of commencing treatment without delay in untreated subjects with home BP >135/85 mm Hg should be evaluated with caution.

In the subjects with lower (normal) home BP, 24-hour ABP monitoring may be useful to investigate whether BP is elevated under different conditions (ie, at work, during the night, and in different home situations). On the basis of results of ABP monitoring, the individuals with low daytime ABP (ie, possibly <130/80 mm Hg: WCH) may be good candidates for lifestyle measures without immediate commencement of drug treatment. However, in the case of coexistence of diabetes mellitus, target-organ damage, or other risk factors, these subjects should not be considered a low risk. Appropriate reference to guidelines to assess suitability of treatment is recommended.

Among the subjects with abnormal daytime ABP levels, a nondipping or, even worse, a “reverse-dipping” BP pattern or an elevated 24-hour pulse pressure would be useful to identify
high-risk individuals suitable to commence drug treatment without delay. Indications from guidelines would remain mandatory in subjects with intermediate risk based on ABP.63

**Head-to-Head Comparisons Between Home BP and 24-Hour ABP**

**Target-Organ Damage**
The degree of association between left ventricular mass and BP is similar when comparing home BP with the average 24-hour ABP.67–69 In one study, left ventricular mass was associated more closely with 24-hour ABP than it was with home BP.69 In other studies, different markers of organ damage, including the urinary albumin excretion69 and the carotid intima-media thickness,68 showed a comparable degree of association with home BP and 24-hour ABP. In all of these studies, office BP generally showed a lesser degree of association with organ damage when compared with home BP and 24-hour ABP.67–70 Overall, these data suggest that home BP and 24-hour ABP are equally reliable, and superior to clinic BP, for prediction of target-organ damage in hypertensive patients.

**Major Cardiovascular Events**
In the Pressioni Arteriose Monitorate e Loro Associazioni Study, a general population study, both home BP and 24-hour ABP were predictive of the risk of all-cause and cardiovascular mortality, however, without a clear superiority over clinic BP.22 In another population study from Belgium, a composite pool of major cardiovascular events was equally predicted by home BP and average daytime ABP, whereas nighttime BP showed superior prognostic value.21

Of particular note, none of the available studies compared the prognostic impact of home BP with that of 24-hour ABP in hypertensive patients. All of the available data come from population studies conducted in a composite of normotensive and hypertensive subjects, some treated and some untreated at the time of home BP and 24-hour ABP recording.

**Conclusions**
It is out of question that the prognostic value of 24-hour ABP is more strongly supported than that of home BP, particularly in subjects with hypertension. As clinicians, we should exploit the best information that home BP and 24-hour ABP can provide.

The 2007 European Society of Hypertension/European Society of Cardiology guidelines71 and the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure72 present lists of general indications for 24-hour ABP, which share the substantial uncertainty for the reliability of clinic BP in the listed situations (unusual variability of BP, apparent resistance to drug treatment, hypotension, suspected WCH, etc.).

As far as home BP is concerned, whereas the European guidelines remark on its role in the management of treated hypertensive patients,71 the Joint National Committee guidelines emphasize the role of home BP as first-line procedure, mostly to establish whether an antihypertensive treatment is needed, as well as for the assessment of BP in smokers.72

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**Table 3. Indications for 24-Hour ABP and Home BP Monitoring**

<table>
<thead>
<tr>
<th>European Society of Hypertension/European Society of Cardiology Recommendations67</th>
<th>24-h ABP</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Considerable variability of clinic BP over the same or different visits</td>
<td>(a) Suspected WCH in patients with hypertension and no target-organ damage</td>
</tr>
<tr>
<td>(b) High clinic BP measured in subjects otherwise at low total cardiovascular risk</td>
<td>(b) Apparent drug resistance (office resistance)</td>
</tr>
<tr>
<td>(c) Marked discrepancy between BP values measured in the office and at home</td>
<td>(c) Hypotensive symptoms with antihypertensive medication</td>
</tr>
<tr>
<td>(d) Resistance to drug treatment suspected</td>
<td>(d) Episodic hypertension</td>
</tr>
<tr>
<td>(e) Hypotensive episodes suspected (particularly in elderly and diabetic patients)</td>
<td>(e) Autonomic dysfunction</td>
</tr>
<tr>
<td>(f) Office BP elevated in pregnant women and pre-eclampsia suspected</td>
<td>Home BP</td>
</tr>
<tr>
<td></td>
<td>(a) Provide more information on the blood pressure-lowering effect of treatment at trough and, thus, on therapeutic coverage throughout the dose-to-dose time interval</td>
</tr>
<tr>
<td></td>
<td>(b) Improve patient’s adherence to treatment regimens</td>
</tr>
<tr>
<td></td>
<td>(c) Doubts on technical reliability/environmental conditions of ABP</td>
</tr>
<tr>
<td></td>
<td>Seventh Joint National Committee recommendations68</td>
</tr>
<tr>
<td></td>
<td>24-h ABP</td>
</tr>
<tr>
<td></td>
<td>(a) To assess differences between office and out-of-office BP before consideration of ambulatory monitoring</td>
</tr>
<tr>
<td></td>
<td>(b) Assessment of BP in smokers</td>
</tr>
</tbody>
</table>

Recently, a consensus conference on home BP monitoring substantially endorsed the European Hypertension Guidelines in suggesting the potential indication for home BP monitoring in “all patients receiving antihypertensive medications, evaluation of WCH, evaluation of masked hypertension, evaluation of resistant hypertension, to improve compliance and medical adherence, to improve hypertension control rate.”71

In the clinical practice, 24-hour ABP monitoring may be unsuitable for the long-term management of most treated hypertensive patients. A policy of periodical 24-hour ABP monitoring sessions in the majority of patients would be unrealistic, expensive, badly accepted by patients, and unsupported by literature. Only in a limited number of clinical conditions, outlined by guidelines,71,72 (Table 3) should 24-hour ABP be considered in treated hypertensive patients. In contrast, although more longitudinal data are needed in this area, home BP would appear most suitable for the long-term management of patients, similar to what happens with the monitoring of glycemia at home in diabetics.

A strong case for 24-hour ABP monitoring in almost all subjects would be the initial assessment for untreated individuals with a clinical diagnosis of hypertension. In these subjects, 24-hour ABP monitoring would contribute impor-
tantly to refine risk stratification and support therapeutic decisions. Because its prognostic value is so largely supported, 24-hour ABP monitoring may be useful, in our opinion, also for untreated subjects with office hypertension and normal home BP who lack target-organ damage. There is no evidence supporting the prognostic value of home BP in these subjects. Such a position differs from that of the seventh Joint National Committee guidelines.

International registries gathering together many thousands of subjects who underwent 24-hour ABP monitoring in different centers under comparable experimental conditions are providing a growing mass of useful information on the prognostic value of 24-hour ABP.

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**Disclosures**

None.

**References**


Response to Home Blood Pressure Measurements Will Not Replace 24-Hour Ambulatory Blood Pressure Monitoring

Gianfranco Parati, Stefano Omboni, Grzegorz Bilo

The story of the battle of Thermopylae mentioned by Verdecchia et al is only complete when the final outcome of the war between Spartans and Persians is considered. Despite their overwhelming numeric superiority, the Persians were finally defeated at Salamis and Plataea and forced to withdraw from Greece. Thus, history seems to teach us that, although the prognostic evidence supporting ambulatory blood pressure monitoring (ABPM) may seem unbeatable, the hopes of home blood pressure measurements (HBPM) are by no means lost, thanks to its numerous virtues including the advanced technologies currently available.

We fully agree that at present HBPM and ABPM are complementary techniques with partly overlapping applications. However, we would not agree to underestimate the value of HBPM simply because of the larger number of outcome studies on ABPM, a difference mostly explained by the fact that reliable HBPM devices have become largely available only recently. Moreover, the evidence supporting HBPM points exactly to the same conclusions as in ABPM studies, and the few available face-to-face prognostic studies of ABPM and HBPM demonstrated that they are comparable in this regard. Although the prognostic value of HBPM was not specifically assessed in untreated hypertensive patients, it was clearly demonstrated in the general population of the PAMELA and the Ohasama studies; thus, we see no reason to believe that it is limited to treated subjects only. Given that routine use of ABPM in the initial evaluation of all potentially hypertensive subjects is not feasible, HBPM should therefore be considered the first choice in clinical practice, whereas ABPM should be performed in selected cases only, as indicated in recent hypertension guidelines. There may well be different individual opinions on this issue. This should not prevent hypertension experts from taking a common position at least on the strong need of expanding out-of-office BP monitoring, however obtained, in the routine management of hypertensive patients.
Home Blood Pressure Measurements Will Not Replace 24-Hour Ambulatory Blood Pressure Monitoring
Paolo Verdecchia, Fabio Angeli, Giovanni Mazzotta, Giorgio Gentile and Gianpaolo Reboldi

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