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Ambulatory Blood Pressure Monitoring Is Ready to Replace Clinic Blood Pressure in the Diagnosis of Hypertension

Pro Side of the Argument

Geoffrey A. Head

Since the introduction of lightweight ambulatory blood pressure (BP) monitoring (ABPM) devices into clinical use in the late 1980s, there has been a huge increase in their contribution not only to fundamental research on the diurnal patterns of BP in humans, but increasingly for the diagnosis of hypertension. Clearly, the recognition of the value of multiple readings for accuracy and the detection of white coat, masked, and nocturnal hypertension has been critical to correctly determine the extent and impact of hypertension in the community. Importantly, the prognostic value of ABPM for cardiovascular events has been a major impetus for the promotion of its widespread adoption in primary care. National and International guidelines have largely been supportive of this move, and the United Kingdom leads the way by adopting ABPM to diagnose hypertension in primary care.[1] Thus, the question of whether ABPM is ready to replace clinic measurements for the diagnosis of hypertension is passé for some but still relevant for others. In either case, the arguments for and against need to be carefully considered as there are major implications to the way cardiovascular healthcare services are delivered. The case for using ABPM for the diagnosis is strong given that clinic measurements even when performed to best practice standards misdiagnose hypertension in ≈30% of individuals (see below). The evidence is so convincing that the medico-legal issue of NOT performing ABPM to diagnose hypertension has been raised.[2] On the contrary, there is resistance to using ABPM particularly in some quarters exemplified by the editorial in 2011 that suggested that ABPM is not ready for prime time.[3] The arguments presented are largely related to resources and costs and suggested alternatives.

In order therefore to consider this important question, we need to first evaluate the medical imperative for the use of ABPM over other alternatives to determine whether they match the diagnostic sensitivity of ABPM. Second, we need to determine whether the barriers of implementation really exist or whether they are simply inertia to change. It is understandable that the office/clinic measurement of BP has been the cornerstone of clinical screening for hypertension, but is also used for a myriad of other reasons in assessing patient's health and condition. This should continue and be improved with wider use of automated office BP devices. However, the proper diagnosis of hypertension requires a much more accurate assessment of the patient's BP during their normal active life, during the night, and importantly, during the sleeping period, which is afforded only by ABPM. Although the current brief is to support the case that ABPM is ready to replace clinic BP in the diagnosis of hypertension, it is not to discuss the growing support for the use of ABPM in guiding drug treatment or 24-hour efficacy of drug treatment, which is a separate but still important issue.

ABPM Is the Most Accurate Method for Diagnosis

Of the 3 most common modalities for the assessment of BP, clinic, home, and ambulatory, the latter has been well recognized to best reflect the individual's BP profile over the 24-hour period.[4,5] Current estimates from 3 studies suggest that clinic

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BP assessments misdiagnose hypertension in 9%,[6] 12%,[7] and 18%[5] of the general population where the measurements are sufficiently above the hypertension threshold of 140/90 mm Hg in the office but below threshold outside the office. This phenomenon was defined by Pickering and colleagues as White Coat or isolated clinic hypertension[8] and is thought to be largely because of the stress of the occasion.[9] Conversely, a further ≈10% are misdiagnosed by clinic measurements when the patient's BP levels are below the hypertension threshold in the office but are above outside the office.[10,11] This is termed masked hypertension.[12] Thus, taken together, misdiagnosis can occur in 20% to 30% of patients if classified with clinic assessments.

The Prognostic Value of Ambulatory BP Monitoring

One of the strongest arguments for the use of ABPM over clinic BP has come from its greater prognostic value. This presumably derives from the sheer number of recordings, likely giving a more reliable measure of the patient's real BP. Further, the 24-hour assessments include multiple measurements during the normal person's daily schedule, measurements at night reflecting the importance of BP dipping. Thus, it is not at all surprising that so many prospective studies have found that ABP measurements are a much stronger predictor of clinical outcomes than clinic BP assessments.[13–30] End-organ damage associated with elevated BP, such as left ventricular hypertrophy, is more strongly correlated with ABP than with clinic BP measurements.[31–34] ABPM also correlates more closely with renal and vascular surrogate markers of end-organ damage, such as microalbuminuria and carotid artery wall thickness, respectively.[35] Of the ABPM measures, night time BP is a stronger predictor of end-organ damage than daytime BP.[29] The well-accepted underlying argument is that the end organ damage is a surrogate for the long-term level of BP of the individual patient. Since ABPM is clearly ahead of other BP measure in this regard, it likely better reflects the true BP of the patient.

The inaccuracies of clinic measurements are well described, but in the main they are caused by the relatively few measurements taken under often less than optimal conditions. Further, neither clinic nor home BP assessments include nocturnal BP. There have been few direct comparisons between clinic, home, and ABPM as to which is the best predictor of outcome. The study Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) found that both home and ABPM were similar in their prognostic ability, but this study was limited in that no cofounders were adjusted for, cardiovascular mortality was the only end point, and home measurement consisted of only 2 readings.[29] Further, the predictive capacity of the 3 methods was based on only 56 end points, too few to be meaningful. Recently, Niiranen et al[36] directly compared the prognostic value of ABPM and Clinic BP in predicting cardiovascular mortality, myocardial infarction, stroke, heart failure hospitalization, and coronary intervention in 502 participants followed up for 16 years. When all BP measures were included in the multivariate adjusted Cox models, only systolic and diastolic ambulatory BP was a predictor, indicating the ABPM is superior to office measurements.[36] Importantly, the office BP was meticulously determined by a nurse after 15 minutes rest using 4 duplicate measures at weekly intervals.

What Do the Guidelines Say?

In the last 5 years, several guideline updates have included ABPM and have made much stronger recommendations for its use. In particular, The National Institute of Clinical Excellence in the United Kingdom in 2011 stated "If the clinic BP is 140/90 mm Hg or higher, offer ABPM to confirm the diagnosis of hypertension."[37] This recommendation was the result of an exhaustive systematic review of the literature (over 600 papers) and grading of the evidence which is presented in table form. Although only a selection of these papers referred to the issue of measurement of BP, the analysis of primary papers and many meta-analyses provided clear evidence that although home BP assessments were superior to clinic measurements for the diagnosis of hypertension, they were not as good as ABPM.[37] The Australian ABPM consensus statement recommended clinic blood for screening and a combination of ambulatory, home, and clinic measurements for diagnosis of hypertension.[38] More recently, the European Society of Hypertension working group on BP monitoring released a most comprehensive position statement[39] and also a practice document.[40] The European Society of Hypertension working group strongly recommends that ABPM should be performed whenever possible in subjects with suspected hypertension in whom it is necessary to confirm the diagnosis of sustained hypertension. In Japan, the 2012 revised guidelines for the use of ABPM suggests that the procedure should not be used as a routine procedure, but was an excellent tool for detailed evaluation of BP during normal daily life. The committee suggested it should be used only for those with large variability of BP or suspected white coat, masked, or resistant hypertension.[41] In reality, how does one suspect white coat hypertension without the use of ABPM or other out of office techniques. As in the United States, ABPM has been reimbursed in the Japanese National Health Insurance scheme, which recognized the superiority of ABPM over casual BP measurements for predicting the development of cerebral and cardiovascular complications.[41]

The approach of the Canadian Hypertension Education Program recommendation for management of hypertension published in 2010, which is still current, follows a logical algorithm of ≥2 office visits with BP elevated above the standard hypertension threshold (140/90mmHg) to be confirmed for diagnosis by either (i) 3 further office visits with average values above threshold, (ii) an ABPM, or (iii) home BP measurements. Thus, although there is a degree of flexibility in which BP technique can be used for the diagnosis of hypertension in the Canadian recommendations, there is a clear support for ABPM and home measurements, which are recommended with higher level of evidence (Grade C) compared with clinic measurements (grade D). Inherent in the guidance is recognition of the poor reproducibility of clinic measurements requiring 5 clinic visits to confirm diagnosis of grade 1 hypertension compared with a single ABPM.

Guidelines tend to be conservative by nature, but most panels are clearly recognizing the issues related to the inaccuracy of clinic BP and the value of ABPM not only in special cases

but more generally for the most accurate assessment of the patients' BP but also for the diagnosis of hypertension. The National Institute of Clinical Excellence (UK) recommendation provides the most thorough analysis of the issue, and although the recommendation was controversial,[42] the advice is hard to refute given the extent of the evidence presented.

Are There Hypertension Definitions and Thresholds for ABPM?

A prerequisite for the readiness of using ABPM to replace clinic BP for the diagnosis of hypertension is the need for a comprehensive set of thresholds to define hypertension and guide treatment in both low and high risk patients. These are well documented for clinic BP and are in the main similar across the various national guidelines (see Table 6 in James et al).[43] These are now available for ABPM[38] as well after a study that used a regression technique based on paired clinic and ABPM readings from over 5000 patients to determine ABPM equivalents (Table 1).[44] The level of these thresholds based on the Australian National Heart Foundation guideline[45] was partly validated by the finding that the method predicted exactly the internationally accepted levels of daytime, night time, and 24 hour ABPM equivalents for the hypertension threshold of 140/90 (Table 2).[37,39,41,46,47] Further they closely matched the values determined by the International Database on Ambulatory BP and Cardiovascular Outcomes study, which used an outcome measure equivalent to determine the ABPM threshold for hypertension.[48] Thus, a clear and valid framework for using ABPM in the diagnosis and treatment of hypertension in low and high risk patients is now available.

Do Barriers to Using ABPM Really Exist?

The influence that ABPM has on clinical practice clearly varies from country to country depending on ease of availability, cost, patient engagement, and importantly, the attitude of treating physicians. However, there has been some resistance to the concept of using ABPM to replace clinic BP. An editorial that responded to the publication of the National Institute of Clinical Excellence (UK) guideline in 2011 suggested that ABPM was not ready for prime time in the United States.[3] The reason was given that without appropriate reimbursement from third-party payers in the United States, the equipment, staffing, and training costs to implement a similar recommendation for ABPM would be overwhelming. A similar message was reported by a spokesperson from The Royal Australian College of General Practitioners who were supportive of ABPM, but they were not pushing for a medical rebate because of costs and practical issues, such as training staff, and that home monitoring was simpler.[49] The question of whether these barriers are real or not is therefore of decisive importance.

Advances in ABPM Technology, Availability of Suitable Devices and Training

Novel technological developments, including cloud based remote monitoring, integration into clinic patient management software, and new low patient impact devices that exist today, have removed many of the major barriers to the routine use of ABPM for diagnosis and management of hypertension. There are now a large number of smaller and lighter ambulatory devices, with some giving 24 hour measurement of central systolic, diastolic, and pulse pressure. According to the Medicalexpo web site, there are 30 companies offering 44 products for ambulatory BP. Nearly all have passed one of the accreditation schemes such as Association for the Advancement of Medical Instrumentation, British Hypertension Society, and European Society of Hypertension testing regimes. Some models offer dual cuffs for first visit screening. The integration and use of standardized analysis by easy-to-use software offers doctors an instant guide to the interpretation. Most software offers the standard measures of 24 hour, day night, awake, and asleep summary data, whereas some include circadian analysis, options for actigraphy to detect sleep, as well as online upload and analysis. Alternatively, detailed simplified guide to the use of standardized report information, as well as examples and interpretation, are available from the Australian ABPM consensus Committee[50] as well as from the European

Table 1. Classification of Hypertension and Treatment Targets for Adults According to Clinic Blood Pressure[45] Mathematically Derived From the Relationship Between Clinic and ABPM[38]

		ABP Predicted From Clinic BP (mm Hg)		
Hypertension Thresholds	Clinic BP	24-h	Night	Day
Grade 3 (severe)	180/110	165/100	160/95	170/105
Grade 2 (moderate; JNC7 Stage 2)[43]	160/100	150/90	140/85	150/95
Grade 1 (mild/uncomplicated hypertension;* JNC7 Stage 1)[43]	140/90	130/80	120/75	135/85
Patients with associated clinical conditions or end-organ damage†	130/80	125/75	110/65	130/80
Hypertension plus proteinuria >1 g/d	125/75	120/70	110/65	125/75

Hypertension thresholds and targets are based on the National Heart Foundation of Australia definition[45] and were equivalent for JNC7.[43] Predicted mean systolic/diastolic ABP values rounded to the nearest 5 mm Hg corresponding to specific clinic BP levels and targets (upper limits) that are used in grading hypertension based on clinic BP measured by trained staff other than doctors.[44]

ABP indicates ambulatory blood pressure; ABPM, ambulatory blood pressure monitoring; BP, blood pressure; and JNC7, Seventh Joint National Committee.

*People without any of the following: coronary heart disease, diabetes mellitus, chronic kidney disease, proteinuria (>300 mg/d), stroke, or transient ischemic attack.

†People without any conditions listed at note [*].

Table 2. Comparison of National Recommendations for Ambulatory BP Equivalents of Hypertension Threshold Clinic Values of 140/90 mm Hg

National Guideline	Clinic BP	ABP Equivalents, mm Hg		
		24 h	Night	Day
Seventh Joint National Committee (USA, 2003)[43]	140/90	Not stated	120/75	135/85
European Society of Hypertension (2013)[39]	140/90	130/80	120/70	135/85
Japanese Circulation Society (2012)[41]	140/90	130/80	120/70	135/85
Canadian Hypertension Society(1999)[46]	140/90	130/80	120/75	135/85
Australian National Heart Foundation and High BP Research Council Consensus (2012)[38]	140/90	130/80	120/75	135/85
National Institute for Health and Clinical Excellence (UK, 2011)[37]	140/90	Not stated	Not stated	135/85

All values in mm Hg. Note that the only discrepancy is for night time diastolic BP.
ABP indicates ambulatory blood pressure; and BP, blood pressure.

Society of Hypertension.[51] Cloud-based centralized storage from blue tooth devices connected to smartphones also simplifies the uploading of the 24 hour profile, taking the hassle out of retrieving the data from the patient. As for training, this is no different and could be suggested as actually being easier than training staff to measure by traditional methods of BP measurement. It is clear that technology has and will continue to remove what can now only be conceived as a perception of a barrier rather than perhaps a real concern.

The availability of ABPM varies considerably between different countries and is perhaps one of the major barriers to implementing ABPM for the diagnosis of hypertension. A large study emanating from Ireland has recently examined the results of ABPM from over 46 000 patients attending primary care and nearly 1700 patients with ABPM organized through pharmacies. The values obtained were within 1 mm Hg and generally in good agreement with a similar percentage of white coat hypertension, although more people attending pharmacies were hypertensive.[52] Nevertheless, the overall BP characteristics were similar. Thus, performing ABPM in Pharmacies is feasible and provides a useful adjunct to make ABPM much more accessible.[52] Further, this study is an excellent example of the use of advanced centralized computer technology such as dabl for the collection, analysis, and dissemination of ABPM recording information,[53] thus, reducing the burden on doctor's and clinic staff time and empowering the patient in the management of their hypertension.[2]

Cost-Benefit of Using ABPM for the Diagnosis of Hypertension

Formal cost-benefit analysis has consistently shown that ABPM reduces costs.[54–56] In Japan, it was estimated that introduction of ABPM for hypertension would result in a saving of 10 trillion yen over 10 years, saving nearly 10 000 lives and reducing strokes by nearly 60 000.[57] Positive steps in the United Kingdom and Europe are encouraging, including the 2011 modeling study on the cost effectiveness of 3 methods of primary care diagnosis of hypertension, which indicated robust cost savings for ABPM.[58] Lovibond and colleagues[58] suggested that ABPM would reduce misdiagnosis, reduce costs, and any additional costs from ambulatory monitoring are counterbalanced by cost savings from better targeted treatment. In primary care in Portugal, widespread use of ABPM for patients with suspected hypertension increases the diagnostic accuracy and improves cardiovascular risk stratification.[59] Importantly, ABPM use reduces health costs, showing a highly favorable benefit–cost ratio compared with a strategy without ABPM.[59] For the United States, Krakoff estimated a cost saving of 3% to 14% for cost of care for hypertension using ABPM for newly detected hypertensive subjects.[60] Importantly, there were savings when the total annual cost of care was as little as $300. Similarly in Australia, a small but thorough study showed an overall 13% cost reduction to the pharmaceutical benefits scheme over 7 years and that the cost of ABPM was offset in the first year by less unnecessary treatment.[61] A recent study suggests that there may be additional savings by using a chronotherapy approach, which is enabled by ABPM, for better control of daytime and nighttime BP levels.[62]

Cost of Using ABPM for the Clinic and Patient

Competition has driven costs of devices down considerably and now some device manufacturers are even offering pay-per-use contracts, so there is no initial outlay at all. Reimbursement for ABPM has been considered to be an important issue holding back the implementation of ABPM for routine use. In the Unite States from 2001, ABPM could be claimed under Medicare for suspected white coat hypertensive patients.[63] As in the United States, ABPM has been reimbursed by the Japanese National Health Insurance scheme, which recognized the superiority of ABPM over casual BP measurements for predicting the development of cerebral and cardiovascular complications as well as its excellent cost effectiveness.[41] Further, in the only head-to-head comparison to guide determining antihypertensive treatment, ABPM guided therapy results in overall reduced prescriptions as clinic BP, while maintaining equal BP control and being as effective in reducing end-organ damage.[64] In Australia, there is no rebate for ABPM, but advertised costs even in regional centers in Victoria are advertised as low as $40 for ABPM and $20 for concession holders. This equates to the cost to the patient of 1 month of a subsidized single antihypertensive agent.

For the clinic, cost recovery is a critical issue, and in the United States, in particular, the average cost of ABPM is considered to be high, but so are additional consultations that

would be required to properly confirm diagnosis. The current debate is often fixated on what we have always done in the past, and the power to make change through opening new markets and increased competition is not often considered. Not only are costs diminishing through technology, the proclamation of using ABPM for the routine diagnosis of hypertension will drive up the availability and drive down the costs. To use the argument that we are not ready to do this because the costs are too high or the tests are not easily available is not one that would be considered at all valid by innovators, such as Thomas Edison or Henry Ford. By creating the demand, you create the solution. The cost benefit analysis has already been done.

From the patient's perspective, there is no doubt that faced with a choice of lifetime antihypertensive drug treatment or confirmation by a 24-hour ABPM test, the latter would be preferable, particularly for white coat hypertensive. This does not mean that they will always be able to remain treatment free as these patients eventually develop true hypertension in 1 to 2 years.

Are There Realistic Alternatives?

Automated Office BP

The final question to consider is whether there are realistic alternatives that make ABPM unnecessary. One such technique is automated office BP measurements that have been shown to increase accuracy, reduce the white coat effect, and give values equivalent of daytime ABP.[65,66] Indeed, it has also been suggested that automated office BP is as good as home BP for assessing morning hypertension.[67] However, a recent head-to-head comparison failed to show that automated office BP measurement improved classification errors compared with manual methods, although some lessening of the white coat effect was observed.[68]

Home or Self-Measurement of BP

Although the measurement of BP at home by the patient is an attractive option,[69] there are considerations. For the diagnosis of hypertension, the patient is required to follow a demanding routine of measure twice in the morning and twice in the evening for 7 days, discarding the first day to gain an average of 12 readings.[51] Importantly, home BP does not determine nocturnal BP, which is known to be the strongest predictor of outcome. The panel evaluating ABPM for Medicare in the United States stated It is important to note that self-measurement of home BP is not considered as a true alternative to ABPM.[63] Home BP measurement can underestimate white coat hypertension and overestimate masked hypertension if the cuff size is wrong (normal instead of large) in patients with large arms.[70] In terms of time and effort by the clinician, the training of staff to train the patient, gather the data, and interpret the findings exists for home BP assessment and is not too dissimilar to what is required for ABPM. Of concern is the quality of the readings, the patient bias, and the issue of the self–test induced effect (parallel to the white coat effect in the office). Importantly, home BP does not determine nocturnal BP, which is known to be the strongest predictor of outcome. One of the only direct comparisons between measurement methods is that ABPM was a far superior predictor of cardiovascular outcome than home.[36] An important additional observation was that the home measurements measured in the evening and morning for a week were 8/9 mm Hg less than daytime ABP, which suggest that home measurements did not accurately reflect normal daily life levels of BP. Thus, home BP has its place in conjunction with ABPM, but it should not be considered as an alternative unless ABPM is not tolerated. This is the current position of several guidelines, including those in the United Kingdom and Australia.[37,38]

Conclusions

After consideration of the issues, it is clear that there is compelling evidence to support the use of ABPM for the diagnosis of hypertension. Indeed, there would be concern from patient's perspective if there was not a careful and accurate assessment of BP using the gold standard noninvasive method, before embarking, or not as the case may be, with antihypertensive therapy. Indeed, the medico-legal issue of not providing ABPM to patient's in the light of the overwhelming recommendations for the use of ABPM to diagnose hypertension as raised recently by O'Brien[2] may prove to be the final tipping point. The procedure is no more arduous than many others currently in use today for diagnosis of various conditions. The alternatives are not robust enough as yet, nor is the cost of ABPM a valid dissuader for its use. Are we ready now? Indeed, but the readiness does differ from country to country. The United Kingdom has already adopted the change to confirming diagnosis with ABPM into general practice. Given the importance of the outcome for the long-term health of the patient, other countries and regions should be encouraged to follow their lead sooner rather than later. The technological advances, competitive market, pay per use contracts have taken much of the difficulty and cost from the argument for many countries. However, realistically, in the developing world, it may not be affordable or practical at the moment.

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Response to Ambulatory Blood Pressure Monitoring Is Ready to Replace Clinic Blood Pressure in the Diagnosis of Hypertension: Pro Side of the Argument

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The case for replacing clinic measurement of blood pressure (BP) with ambulatory blood pressure monitoring (ABPM) is based on the assumption that ABPM is the most accurate and cost-effective method to diagnose hypertension and assess the risk of hypertension-induced events. Moreover, a large number of reports and recommendations from Scientific Societies and Governmental bodies support this concept. However, before accepting these paradigms, the threshold values and the effect of BP-guided treatment on events should be determined. Threshold values for ABPM have been currently established by regression techniques and not from studies conducted to determine the BP values above which detection and treatment do more good than harm. Likewise, the optimal goals for antihypertensive treatment have not been established. In fact, though there are many studies comparing the effect of treatment on office BP and ABPM, evidence that ambulatory BP-guided treatment reduces morbidity and mortality is still required. Even though there is a large amount of experience and evidence supporting the superiority of ambulatory over office BP in the past years, its full effect remains to be tested over the coming years before the technique can be recommended as a replacement for office BP in the diagnosis and management of hypertension.