Automated office blood pressure measurement in primary care

Martin G. Myers MD FRCPC Janusz Kaczorowski PhD Martin Dawes MB BS MD FRCGP Marshall Godwin MD MSc FCFP

EDITOR'S KEY POINTS

- Blood pressure (BP) readings taken in the office (automated office BP [AOBP]), at home (BP self-measurement), or during usual daily activities (24-hour ambulatory BP monitoring [ABPM]) can improve the assessment of BP status and eliminate white-coat hypertension.

- As AOBP measurement is equivalent to both awake ambulatory BP measurement and home BP measurement, the same cutoffs can be used in a diagnostic algorithm for all 3 automated measurement techniques.

- The preferred method for evaluating an individual's BP status in relation to the risk of experiencing future cardiovascular events is ABPM. Home BP measurement and AOBP measurement can be considered complementary, to be used when ABPM is not available, or to be used when repeated assessment of BP status is required, such as after the initiation of antihypertensive drug therapy.

POINTS DE REPÈRE DU RÉDACTEUR

- Les lectures de la pression artérielle (PA) prises en cabinet (mesure automatisée de la PA en cabinet [PAAC]), à la maison (mesure par le patient de sa PA) ou durant les activités quotidiennes normales (surveillance de la PA ambulatoire sur 24 heures [MPAA]) peuvent améliorer l'évaluation de l'état sur le plan de la PA et éliminer l'hypertension induite par le syndrome de la «blouse blanche».

- Étant donné que la mesure de la PAAC est équivalente à celle de la mesure de la PA ambulatoire en état d'éveil et à la mesure de la PA à domicile, les mêmes valeurs paramètres dans l'algorithme de diagnostic peuvent être utilisées pour les 3 techniques automatisées de mesure.

- La méthode privilégiée pour évaluer la situation d'une personne quant à sa PA en relation avec le risque de subir des incidents cardiovasculaires futurs est la MPAA. La mesure de la PA à domicile et la mesure de la PAAC peuvent être considérées comme étant complémentaires et être utilisées quand la MPAA n'est pas accessible ou servir lorsqu'une évaluation répétée de la PA est nécessaire, comme à la suite de l'amorce d'une pharmacothérapie antihypertensive.

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Abstract

Objective To provide FPs with detailed knowledge of automated office blood pressure (AOBP) measurement, its potential role in primary care, and its proper use in the diagnosis and management of hypertension.

Sources of information Comprehensive monitoring and collection of scientific articles on AOBP by the authors since its introduction.

Main message Automated office blood pressure measurement maintains a role for blood pressure (BP) readings taken in the office setting. Clinical research studies have reported a substantially stronger relationship between awake ambulatory BP measurement and AOBP measurement compared with manual BP recorded during routine visits to the patient's physician. Automated office blood pressure measurement produces mean BP values comparable to awake ambulatory BP and home BP values. Compared with routine manual office BP measurement, AOBP correlates more strongly with awake ambulatory BP measurement, shows less digit preference, is more consistent from visit to visit, is similar both within and outside of the physician's office, virtually eliminates office-induced hypertension, and is associated with less masked hypertension. It is estimated that more than 25% of Canadian primary care physicians are now using AOBP measurement in their office practices. The use of AOBP to diagnose hypertension has been recommended by the Canadian Hypertension Education Program since 2010.

Conclusion There is now sufficient evidence to incorporate AOBP measurement into primary care as an alternative to manual BP measurement.

Mesure de la pression artérielle automatisée en cabinet de soins primaires

Résumé

Objectif Fournir aux MF des renseignements détaillés sur la mesure de la pression artérielle automatisée en cabinet (PAAC), son rôle potentiel dans les soins primaires et son utilisation appropriée dans le diagnostic et la prise en charge de l'hypertension.

Sources des données Une surveillance rigoureuse et la collecte d'articles scientifiques sur la PAAC par les auteurs depuis son instauration.

Message principal La mesure de la pression artérielle automatisée en cabinet continue de jouer un rôle dans la lecture de la pression artérielle (PA) dans le contexte d'un bureau de médecin. Des études de recherche clinique ont signalé une relation considérablement plus forte entre la mesure de la PA ambulatoire en état d'éveil et la mesure de la PAAC par rapport à la mesure manuelle de la PA durant les visites habituelles du patient chez son médecin. La mesure de la pression artérielle automatisée en cabinet produit des valeurs moyennes comparables à celles de la PA ambulatoire en état d'éveil et aux valeurs de la PA à domicile. En comparaison de la mesure systématique manuelle en cabinet de la PA, la PAAC a une plus forte corrélation avec la mesure ambulatoire en état d'éveil, a une moins grande partialité sur le plan numérique, est plus constante d'une visite à l'autre, est semblable au bureau du médecin et à la maison, élimine essentiellement l'hypertension causée en cabinet par le milieu et est associée à moins d'hypertension masquée. On estime que plus de 25 % des médecins de soins primaires canadiens utilisent maintenant la PAAC dans leur pratique en cabinet. Le Programme éducatif canadien sur l'hypertension recommande depuis 2010 l'utilisation de la PAAC pour diagnostiquer l'hypertension.

Conclusion Les données probantes actuelles sont actuellement suffisantes pour appuyer l'intégration de la mesure de la PAAC dans les soins primaires comme option de rechange à la mesure manuelle de la PA.

Case

A 66-year-old woman visits her FP for assessment of her blood pressure (BP). A BP reading taken at her neighbourhood pharmacy was 156/84 mm Hg and she became concerned about having hypertension. After she waited for several minutes, her FP called her in and asked her how she was doing. She related her concerns about the BP reading taken at the pharmacy. While chatting with her further, the FP measured her BP using a mercury sphygmomanometer and noted a reading of 170/85 mm Hg. The FP discussed possible lifestyle changes that might help lower her BP and raised the possibility of long-term drug therapy for hypertension in the future. Arrangements were then made for the patient to return for follow-up. The patient did not like the idea of having to take medication and decided to purchase a device for self-measurement of BP at home in order to monitor her own BP.

Several weeks later, she returned to the clinic. She showed the FP a list of BP readings which, at a glance, seemed to average about 130/75 mm Hg. The FP took another reading and recorded her BP as 150/80 mm Hg. Her physician was now in the difficult position of having to decide which readings to accept as a measure of her true BP status.

Sources of information

The authors, who are all experts in the field of BP measurement, have performed a comprehensive monitoring and collection of all scientific publications on AOBP since its introduction.

Main message

Limitations of routine manual BP measurement. The scenario above demonstrates several aspects of our current approach to diagnosing hypertension in primary care practice. Manual BP measurement is accurate when there is strict adherence to a BP measurement protocol, but readings might still be subject to "white-coat effect" and are often higher than BP measurements taken outside of the office setting. In the real world of everyday practice, physician and patient factors such as conversation during BP readings, recording of only a single BP reading, no antecedent period of rest before BP measurement, rapid deflation of the cuff, and digit preference with rounding off of readings to 0 or 5 all adversely affect the accuracy of manual BP measurement. The net result is a reading in routine clinical practice that is on average 9/6 mm Hg higher than BP taken in accordance with standardized guidelines for BP measurement in a research setting (**Table 1**).[1-6] Consequently, routine manual office BP (MOBP) has come to be regarded as an inferior method for diagnosing and managing hypertension. Even when performed properly in research studies, manual BP measurement is a relatively poor predictor of cardiovascular risk related to BP status compared with methods of out-of-office BP measurement such as 24-hour ambulatory BP monitoring (ABPM) or home BP measurement.[7,8]

Home BP measurement and ABPM. Concern about the utility of MOBP led to the Canadian Hypertension Education Program (CHEP) introducing an algorithm for diagnosing hypertension incorporating ABPM and home BP measurement as being preferable to MOBP measurement.[9] More recently, the comprehensive National Institute for Health and Clinical Excellence (NICE) policy review recommended ABPM as the optimum method for diagnosing hypertension in community practice.[10] Data from numerous clinical outcome studies support the use of ABPM and home BP measurement for determining the contribution of BP to an individual's risk of experiencing future cardiovascular events.[7,8]

In the above case history, the home BP readings were much lower than the single manual BP recorded by the physician. This scenario illustrates one of the main concerns about relying on home BP measurement for determining a patient's out-of-office BP status. Home BP readings collated by the patient are subject to

Table 1. Mean BP readings taken manually in primary care practice by the patient's physician and readings taken using a mercury sphygmomanometer as part of a research study: *Overall mean BP in routine clinical practice was 154/91 mm Hg, and overall mean BP in the research studies was 145/85 mm Hg.*

		BP MEASUREMENT, mm Hg	
STUDY	NO. OF PATIENTS	ROUTINE CLINICAL PRACTICE	RESEARCH STUDY
Myers et al,[1] 1995	147	146/87	140/83
Brown et al,[2] 2001	611	161/95	152/85
Graves et al,[3] 2003	104	152/84	140/80
Gustavsen et al,[4] 2003	420	165/104	156/100
Myers et al,[5] 2009	309	152/87	140/80
Head et al,[6] 2010	6817	150/89	142/82

BP—blood pressure.

reporting bias,[11,12] a phenomenon seen not only with BP measurement but also with home glucose monitoring[13] and bronchodilator inhaler use.[14] When it comes to BP measurement, patients cannot always be relied upon to report the actual BP readings that have been taken. As in this case, a patient who was not keen on taking antihypertensive medication might report lower BP readings, whereas another, more concerned about hypertension, might write down high readings. In this instance, the patient had purchased a home BP device with an internal memory for storing all readings. Use of such devices makes it possible for the physician to see the actual mean home BP value and the individual readings if the patient brings the device to the clinic. However, rarely do FPs ask patients to bring their BP devices with them for the memory to be examined. Concern about reporting bias has led to considerable research involving systems that automatically send BP readings by telephone from the home to the clinic via a central data collection centre.[15] Although this approach should eliminate reporting bias, cost considerations will likely limit the use of BP telemonitoring in routine clinical practice in the near future. It should be noted that home BP should be recorded in accordance with CHEP guidelines, which recommend duplicate BP readings taken twice during 7 days when used for diagnosing hypertension.

After a review of all of the published evidence, the CHEP[9] and NICE[10] guidelines concluded that ABPM is the preferred method for determining the BP status of an individual both for the diagnosis of hypertension and for the assessment of response to drug therapy. Another advantage of ABPM is that it records nighttime BP, which can be used to detect patients whose BP remains high during sleep, which is associated with an increased risk of future cardiovascular events.[16] Although some hypertension experts[17] have advocated replacing clinic BP measurement with ABPM and home BP measurement, such a precipitous move might not be necessary or practical at this time.

A key feature of ABPM is that it minimizes the human factor in obtaining BP readings. The ABPM device is fully automated, patients are only required to keep their arms still during a recording, and health professionals need only be present to attach the device and to retrieve it upon completion of the recording. There is no possibility of patient-physician interaction when ABPM readings are being taken. The main disadvantage of ABPM is that it is relatively expensive and somewhat impractical for obtaining readings on multiple occasions.

Automated office BP measurement. Another option for recording BP is automated office BP (AOBP) measurement, which uses a similar approach to ABPM in that a fully automated device records multiple BP readings with no interaction between the patient and physician or nurse.[18] Individual and mean BP readings can be obtained after several minutes with the patient, who is less likely to exhibit a white-coat reaction associated with the presence of a health professional.

Automated office BP measurement originated in Canada with the development of the BpTRU Vital Signs Monitor, a device that takes an initial test reading to verify that a proper BP is being recorded and then automatically performs 5 more readings at prespecified intervals with the observer having left the patient alone and seated in a quiet room.[18] The BpTRU has been validated independent of the manufacturer using standardized protocols.[19,20] Initial studies used the 2-minute setting to record readings during 10 minutes, but subsequent research[21,22] showed that accurate BP readings could be obtained using the 1-minute setting (timed from the start of 1 reading to the start of the next).

The first few studies using AOBP reported much lower readings than routine MOBP did, with the white-coat response associated with clinic BP measurement being substantially reduced or eliminated.[3,23,24] Automated office BP measurement remained somewhat of a curiosity until the publication of a study in 2005 by Beckett and Godwin[25] conducted in primary care practices in the community in which AOBP readings were compared with routine MOBP measurement in 481 patients receiving treatment of hypertension. Automated office BP readings taken with the BpTRU were lower by a mean of 10.8/3.1 mm Hg, with AOBP measurements being similar to mean awake ambulatory BP (AABP) measurements. Moreover, AABP exhibited a substantially stronger correlation with systolic and diastolic AOBP (systolic $r=0.57$ and diastolic $r=0.61$) than with systolic and diastolic routine MOBP (systolic $r=0.15$ and diastolic $r=0.32$).

Similar results were obtained in a series of 309 patients referred to an ABPM unit for 24-hour BP monitoring.[5] In these patients, many of whom were believed to be experiencing white-coat effect, MOBP (mean 152/87 mm Hg) was higher than the mean AOBP of 132/75 mm Hg, which was similar to the mean AABP of 134/77 mm Hg. Once again, the AABP correlated better with AOBP (systolic $r=0.62$ and diastolic $r=0.72$) than MOBP did (systolic $r=0.32$ and diastolic $r=0.48$).

A review of studies performed at the time of writing comparing AOBP with AABP shows mean BP values to be comparable (**Table 2**).[5,21,22,25-30] On the basis of these studies, CHEP has accepted an AOBP reading of 135/85 mm Hg as the cutoff for separating normal AOBP from hypertension.[31]

Other studies have shown AOBP measurement to be consistent from visit to visit and, unlike MOBP measurement, not affected by the setting for BP measurement.[26] Despite AOBP measurement and AABP measurement having the same cutoff for defining hypertension (BP ≥135/85 mm Hg), AOBP measurement does not lead

Table 2. Studies comparing AOBP measurement with AABP measurement: *Mean overall AOBP was 137/79 mm Hg, and mean overall AABP was 137/79 mm Hg.*

STUDY	NO. OF PATIENTS	POPULATION	AOBP, mm Hg	AABP, mm Hg
Myers et al,[5] 2009	309	ABPM unit	132/75	134/77
Myers et al,[21] 2008	200	ABPM unit	133/72	135/76
	200	ABPM unit	132/76	134/77
Myers et al,[22] 2010	139	ABPM unit	141/82	142/81
Beckett and Godwin,[25] 2005	481	Family practice	140/80	142/80
Myers et al,[26] 2009	62	Hypertension clinic	140/77	141/77
Myers,[27] 2010	254	ABPM unit	133/80	135/81
Godwin et al,[28] 2011	654	Family practice	139/80	141/80
Myers et al,[29] 2011	303	Family practice	135/77	133/74
Andreadis et al,[30] 2011	90	Research unit	140/88	136/87

AABP—awake ambulatory BP, ABPM—24-hour ambulatory BP monitoring, AOBP—automated office BP, BP—blood pressure.

to an increase in the prevalence of masked hypertension (normal clinic BP and high AABP or home BP[32]). Readings taken with the BpTRU and Omron HEM-907 showed similar systolic BP values when recorded using the 1-minute and 2-minute interval settings.[33] A slightly lower diastolic BP was seen with the Omron device.

The application of AOBP to routine primary care practice has now been evaluated in Canada in a randomized controlled trial, the CAMBO (Conventional versus Automated Measurement of Blood Pressure in the Office) trial, comparing AOBP with MOBP in the management of 555 patients with hypertension.[29] Using cluster randomization by practice, patients were allocated either to management of their hypertension with the BpTRU device set to take readings at 2-minute intervals or by continuation of previous MOBP measurement that used either a mercury or aneroid sphygmomanometer. The only differences between the 2 groups was the introduction of AOBP into the intervention group and having a target for a normal AOBP of less than 135/85 mm Hg compared with a goal BP of less than 140/90 mm Hg for the conventional MOBP patients.

In the CAMBO trial,[29] patients randomized to the intervention group showed a decrease in BP reading from a routine manual reading of 150/81 mm Hg before entry into the study to an AOBP reading of 136/78 mm Hg during the first clinic visit after enrolment. The corresponding mean AABP reading at baseline was 133/74 mm Hg. A somewhat surprising finding was a fall of 8.5/1.6 mm Hg in the MOBP control group that was attributed to the Hawthorne effect[34] due to participation in a research study. Regression to the mean is another possible explanation for the decrease in BP reading. The occurrence digit preference (rounding off readings to zero values) was reduced to 13% with AOBP measurement but was present in about half of the MOBP readings both before and after entry into the study. Awake ambulatory BP measurement also correlated more strongly with AOBP measurement (r=0.34 and r=0.56) than MOBP measurement did (r=0.22 and r=0.30). Similar findings were seen after 2 years of follow-up.[35] It should be noted that the mean difference between the routine BP recorded in primary care practice and the AOBP in CAMBO (14/3 mm Hg) was similar to the differences reported in previous studies (**Table 1**).[1-6]

Preliminary data have become available linking AOBP with target organ damage. Andreadis et al[30] have recently reported that systolic AOBP correlated with left ventricular mass index (r=0.37) as strongly as AABP did (r=0.37). A clinic reading taken in the presence of research staff correlated poorly with left ventricular mass index (r=0.12). In an earlier study,[1] routine MOBP recorded in primary care practice also correlated poorly (r=0.06) with left ventricular mass index, whereas a manual BP reading recorded in the same setting for research purposes showed a substantially stronger correlation (r=0.27). Automated office BP measurement has also been shown to correlate better with carotid artery intima-media thickness compared with manual BP readings.[36]

Role of AOBP measurement in clinical practice. As AOBP measurement is equivalent to both AABP measurement and home BP measurement, the same cutoffs can be used in a diagnostic algorithm for all 3 automated measurement techniques.[18] This approach simplifies the diagnosis of hypertension in contrast to manual BP measurement, which has a cutoff of 140/90 mm Hg. As recommended by the CHEP[9] and NICE[10] guidelines, ABPM is considered the preferred method for evaluating an individual's BP status in relation to the risk of experiencing future cardiovascular events. Home BP measurement and AOBP measurement can be considered complementary, to be used when ABPM is not available, or to be used when repeated assessment of BP status is required, such as after the initiation of antihypertensive drug therapy. If AOBP and home BP are high, patients can be considered to have

a very high likelihood of hypertension, whereas optimum AOBP and home BP readings of less than 130/80 mm Hg are very likely to be associated with normal AABP readings. Readings in the borderline normal-hypertension range of 130 to 139/80 to 89 mm Hg require further assessment, preferably with ABPM, but alternatively, with a combination of AOBP measurement and home BP measurement if ABPM is not available. Regardless of the method used to record BP, when it comes to deciding on the need for antihypertensive drug therapy, global cardiovascular risk should be the basis for making such decisions, as it includes other risk factors such as smoking, dyslipidemia, target organ damage, and diabetes mellitus.

Automated office BP measurement was incorporated into the CHEP guidelines as an alternative to manual BP measurement for the diagnosis of hypertension in 2010[31] and more than 10 000 automated BP monitors are currently in use in clinical practice in Canada. To date, most of the research into AOBP has used the BpTRU device. Other validated devices for professional use are available and include the Omron HEM-907[38] and the Microlife WatchBP Office.[39] These devices incorporate the same principles for AOBP measurement as the BpTRU in that they enable multiple readings to be recorded automatically with the patient resting alone. It should be noted that not all patients can have reliable AOBP readings taken. For example, most oscillometric devices, including both AOBP and home BP recorders, are less accurate in the presence of arrhythmias such as atrial fibrillation. In these instances, several carefully taken manual BP readings might give a more accurate estimate of a patient's BP status.

Conclusion

Returning to our patient, the FP with access to AOBP could now respond to the conundrum of dealing with a difference between MOBP and home BP. In this case the FP recorded an AOBP of 129/72 mm Hg, confirming that the home BP readings were indeed valid. Thus, BP readings taken in the office (AOBP), at home (BP self-measurement), or during usual daily activities (ABPM) can improve the assessment of BP status and eliminate white-coat hypertension.

Dr Myers is Professor of Medicine at the University of Toronto in Ontario, and a cardiologist in the Schulich Heart Program at Sunnybrook Health Sciences Centre. **Dr Kaczorowski** is the Docteur Sadok Besrour Chair in Family Medicine and GlaxoSmithKline–Canadian Institutes of Health Research Chair in Optimal Management of Chronic Disease in the Department of Family and Emergency Medicine at the Université de Montréal and CRCHUM in Montreal, Que. **Dr Dawes** is a family physician and Professor and Head of Family Practice at the University of British Columbia in Vancouver. **Dr Godwin** is Professor of Family Medicine and Director of the Primary Healthcare Research Unit in the Faculty of Medicine at Memorial University of Newfoundland in St John's.

Contributors
All authors contributed to the literature review and interpretation, and to preparing the manuscript for submission.

Competing interests
None declared

Correspondence
Dr Martin G. Myers, Sunnybrook Health Sciences Centre, Department of Medicine, 2075 Bayview Ave, Toronto, ON M4N 3M5; e-mail **martin.myers@sunnybrook.ca**

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