A Short History of Automated Office Blood Pressure – 15 Years to SPRINT

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The term "automated office blood pressure" (AOBP) refers to BP measurements obtained using a fully automated electronic sphygmomanometer that records multiple BP readings with the patient resting undisturbed in a quiet place without medical staff being present.[1] This article describes the relatively rapid evolution of AOBP from validation studies in 2001 to becoming the preferred method for recording office BP in evidence-based guidelines. The story of AOBP parallels the increased interest in white coat effect (WCE) associated with office BP which is not seen with AOBP measurement.[1]

INTRODUCING THE WHITE COAT PHENOMENON

In 1984, Tom Pickering and colleagues[2] introduced the term "white coat hypertension" (WCH) to describe untreated patients with a high BP in the office and normal BP at home. In 1991, the concept of WCH was extended further, by denoting patients who were already being treated with antihypertensive therapy as having a "white coat effect" if systolic/diastolic office BP was at least 20 and/or 10 Hg higher than awake ambulatory BP.[3] The minimum difference of 20 and/or 10 mm Hg was selected because it was considered to be "clinically important," enough to alter patient management. Also, WCE could be applied to all patients, regardless of treatment status. These definitions are still in use, along with the non-specific terms "white coat phenomenon" and "white coat response."

THE INTRODUCTION OF THE AOBP AND ITS IMPACT

In 1997, Myers and colleagues[4] attempted to eliminate WCE by having patients take their own BP with an electronic home BP recorder while they were seated alone in an examining room. However, under these conditions, some WCE was still present. Shortly thereafter, Gelfer and colleagues at a Canadian medical technology company, VSM MedTech developed the BpTRU, an electronic sphygmomanometer which was capable of automatically taking an initial test reading followed by five readings one or more minutes apart, with the patient resting quietly and alone. Their objective was to reduce WCE by decreasing anxiety associated with the process of BP self-measurement in the office. At this time, a second fully automated, electronic sphygmomanometer, the Omron HEM-907 (Omron Healthcare, Lake Forest, IL, USA), became available for research in AOBP measurement. Both devices were validated for accuracy according to standard protocols.[5–7] Subsequently, the Omron device would receive little attention from the scientific community until re-appearing in 2015 in the SPRINT study.

Beckett and Godwin created considerable interest in AOBP and the WCE in 2005[8] when they reported that BpTRU readings in 481 patients being treated by family physicians in the community reduced routine office BP by 11/3 mm Hg, with the mean automated BpTRU reading being similar to the mean awake ambulatory BP (Table). The multiple readings automatically taken with the BpTRU device with the patient resting quietly and alone became known as "automated office BP" (AOBP) measurement. Within a year, several major research studies using the BpTRU were initiated.

MAJOR STUDIES USING AOBP UNDERTAKEN IN 2006

Kaczorowski and colleagues[9] used the BpTRU for AOBP measurement in the Cardiovascular Health Awareness Program (CHAP), a randomized controlled trial which included BP screening in the community. CHAP is still unique in being the only study in hypertension to demonstrate that screening BP in thousands of community-dwelling subjects can lead to a reduction in hospitalization for cardiovascular events in the future.

Leenen and colleagues[10] became the first researchers to use AOBP in a community BP survey. AOBP was seen to have several advantages over manual BP including more accurate and consistent readings without the need for extensive training of research staff. The Ontario Survey on the Prevalence of High Blood Pressure (ONBP) recorded AOBP using the BpTRU in 2551 adult subjects, with BP readings also being performed using a standard mercury sphygmomanometer in a sample (n=238) of this population.[11] As expected, the AOBP readings were slightly lower (115/71 mm Hg) than the mean manual BP (118/74 mm Hg). Even after adjustment for the differences in BP, treatment and control rates in this population were surprisingly high (65%). Subsequently, Wilkins and colleagues[12] reproduced these findings in a national Canadian health survey, using the BpTRU to assess BP status.

Also in 2006, Myers and colleagues[13] undertook a comparison of AOBP vs manual BP in routine clinical practice in the Conventional vs Automated Measurement of Blood Pressure in the Office (CAMBO) trial. In CAMBO, 555 hypertensive patients residing in 5 urban

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TABLE. Shows Mean BP (mm Hg) Readings Recorded in Routine Office Practice by the Patient's Own Family Physician, Office Readings Recorded by Research Staff, Automated Office BP and Mean Awake Ambulatory BP

Study (Year; reference)	N	Routine Office BP	Research Office BP	Automated Office BP	Awake Ambulatory BP
Myers (1995)[19]	147	146/87	140/83		132/78
Brown (2001)[20]	611	161/95	152/85		139/82
Graves (2003)[21]	104	152/84	138/74	136/79	
Gustavsen (2003)[22]	420	165/104	156/100		147/96
Campbell (2005)[29]	50		139/83	131/76	
Beckett (2005)[8]	481	151/83		140/80	142/80
Dawes (2006)[31]	5918	164/96			149/90
Myers (2008)[15]	200			132/78	135/76
Myers (2008)[15]	200			132/76	134/77
Myers (2008)[11]	238		118/74	115/71	
Myers (2009)[30]	62		140/77		141/77
Myers (2009)[23]	309	153/87	140/80	132/75	134/77
Godwin (2010)[32]	654			139/80	141/80
Myers (2010)[24]	254	150/89		133/80	135/81
Myers (2010)[33]	139		152/84	141/82	142/81
Head (2010)[25]	6817	150/89	142/82		
Andreadis (2011)[18]	90			140/88	136/87
Burgess (2011)[26]	150	145/85	132/79		
De la Sierra (2011)[27]	8295	161/88			136/77
Myers (2011)[28]	303	150/81		133/74	136/78
Myers (2012)[17]	100			137/79	139/80

centers in Eastern Canada were cluster randomized by physician practices to management of their hypertension with either AOBP using the BpTRU or conventional manual BP measurement. In this study, mean AOBP was similar to the mean awake ambulatory BP with both measurements being significantly lower that the manual BP readings in the control group (Table). AOBP also exhibited a significantly stronger correlation with the mean awake ambulatory BP compared to routine manual office BP and was not subject to digit preference (rounding off readings to the nearest zero value). These findings confirmed the benefits of AOBP in "real-world" primary care practice.

OTHER RESEARCH INTO AOBP (2006–2011)

Concurrent with these major trials, a series of smaller studies was undertaken to examine various aspects of AOBP measurement. In a study[14] involving 50 patients referred to a hypertension center, the time course of the decrease in BP readings using the BpTRU set to take readings every 2 minutes was documented. The overall decrease in mean AOBP was 20/5 mm Hg with a 15/4 mm Hg fall in BP seen with the first AOBP reading, indicating that most of the decrease in AOBP occurs soon after the patient is left alone.

In the early studies using AOBP, the interval between readings was set at either 1 or 2 minutes. In 400 patients referred for ABPM, Myers and colleagues[15] showed that AOBP was similar when recorded at either one or two minute intervals, with both mean AOBP values also being similar to the mean awake ambulatory BP. In another study,[16] AOBP readings taken with the BpTRU at one or two minutes were compared to readings taken with the Omron HEM-907, also at one or two minute intervals. Readings taken with each device were similar, except the diastolic reading recorded with the Omron HEM-907 at two minute intervals was slightly lower. In a later study,[17] mean AOBP recorded in 100 patients with a third validated device, the Microlife WatchBP Office (Microlife AG, Widnau, Switzerland), (also called the Welch Allyn PRO BP 2400, Welch-Allyn Inc., Skaneateles Falls, NY, USA) was similar to the mean awake ambulatory BP. Thus, it became possible to perform AOBP using one of three devices during a period of four to 6 minutes.

By 2011, the best evidence for AOBP being a better predictor of target organ damage was in a study by Andreadis and colleagues[18] These authors used echocardiography to obtain estimates of left ventricular mass index, a recognized measure of intermediate target organ damage in hypertensive patients. The measurements were correlated with AOBP, awake ambulatory BP and clinic BP recorded by a technician. The awake systolic ambulatory BP and AOBP both exhibited a stronger correlation (r=0.37) with left ventricular mass index than did the clinic BP (r=0.12). A poor correlation (r=0.06) between routine office BP and left ventricular mass index had also been noted in an earlier study.[19]

AOBP MEASUREMENT IN DIFFERENT LOCATIONS

Most of the initial studies using AOBP were conducted with the patient resting quietly alone in an examining room. This aspect of AOBP was not usually a problem in primary care settings in Canada where most offices

had multiple examining rooms. However, in other countries, such as in Europe and Japan, occupying the only examining room for up to six minutes in order to obtain a BP reading was seen as an obstacle to using AOBP. In taking this position, critics of AOBP failed to take into account the time required to perform a proper manual BP according to established guidelines, five minutes with the patient resting quietly followed by several minutes to record the BP in duplicate. Thus, AOBP takes no longer than a proper manual BP.

By 2012, AOBP had been recorded in a variety of locations, including the offices of primary care physicians[8,28,32], and hypertension (research) specialists[18,21,29], population surveys[11], ABPM units[15,17,23,24,33] and community pharmacies,[9,36] with readings compared to awake ambulatory BP, home BP, routine manual office BP and manual BP recorded under research conditions (Table). For example, AOBP performed in the office of a hypertension specialist in 62 patients was similar to AOBP recorded by a technician in an ABPM unit.[30] Similarly, mean AOBP recorded in 422 patients in the waiting room of the doctor's office while resting quietly, undisturbed, was similar to the mean awake ambulatory BP.[34] In a smaller study involving 19 hypertensive patients, AOBP in a waiting room was similar to AOBP recorded in an examining room.[35] Finally, AOBP recorded in 275 persons attending a community pharmacy was similar to AOBP in the office of their own family physicians.[36] Thus, AOBP readings are not affected by location, provided that the patient is resting quietly and alone when the readings are taken.

AOBP AND SPRINT

The recently completed Systolic Blood Pressure Intervention Trial (SPRINT)[37] used AOBP[38] in determining the optimum target BP for antihypertensive drug therapy. In, SPRINT, BP was recorded using the Omron HEM-907, with the patients resting alone in an examining room. Their protocol included a five minute rest period before the device was activated to record three BP readings automatically, at one minute intervals. In a study comparing the Omron HEM-907 with the BpTRU,[16] there also was a rest period of five minutes before three readings were taken with the Omron device at two minute intervals. Mean systolic BP which was the primary endpoint in SPRINT was the same (132 mm Hg) for both devices. Thus, the method of AOBP measurement used in SPRINT is similar to AOBP as performed in other studies.

It is important to stress that the threshold BP for initiating drug therapy and target BP on treatment in SPRINT cannot be directly extrapolated to current clinical practice. As noted earlier, BP readings in the community are substantially higher than AOBP readings due to a WCE being present in some patients. Since this effect is variable among individuals, it is not practical to use a correction factor to convert manual office BP readings into AOBP. Even if there were some way to adjust for the difference in the readings, it would also be unwise to do so. AOBP is significantly more accurate than manual office BP and is more closely related to awake ambulatory and home BP, both of which are significantly better predictors of future cardiovascular events than manual office BP. Even before the results of SPRINT became available, there was considerable evidence to support replacing manual office BP with AOBP. After SPRINT, there is even more reason to do so.

AOBP AND THE GUIDELINES

In 2011, the Canadian Hypertension Education Program (CHEP) recognized AOBP as being a valuable alternative to manual office BP.[39] By 2015, manual BP was no longer recommended in the CHEP guidelines.[40] The cut-point for normal AOBP was initially set at <135/85 mm Hg on the basis of mean AOBP being similar to the mean awake ambulatory and home BP. In 2015, Myers and colleagues[41] reported the findings in 3627 older persons residing in the community who had an AOBP reading with subsequent follow-up for cardiovascular events over the next 4.9 years. In this untreated population aged over 65 years, a significant increase in cardiovascular risk was seen at a systolic BP of 135–144 mm Hg and at diastolic BP of 80–89 mm Hg. This finding was consistent with the cut-point of 135/85 mm Hg previously derived from comparative BP data. Based upon these and other findings, CHEP has now recommended that AOBP should be the "preferred" method for office BP measurement.

The 2013 ESH/ESC guidelines[42] have also highlighted the advantages of AOBP, stating that, if feasible, AOBP might be considered a means of improving reproducibility and making office BP values closer to the daytime ambulatory and home BP.

In conclusion, there is abundant evidence to support the replacement of manual office BP measurement with AOBP. AOBP readings are more accurate than manual BP and are not subject to the white coat response. There are comparative studies equating AOBP with both ambulatory and home BP and also now clinical outcome data confirming 135/85 mm Hg as the threshold for diagnosing hypertension using AOBP. The CHAP study has demonstrated the advantages of AOBP in the screening of patients in the community for hypertension. The results of SPRINT provide solid evidence in favor of a lower target using AOBP when treating certain high risk hypertensive patients. In order to incorporate the findings of SPRINT and these other cardiovascular outcome studies into clinical practice, AOBP readings should now be used to assess the patient's BP status, both for diagnosing hypertension and for evaluating the response to therapy.

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