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Office Blood Pressure Measurement in the 21st Century

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ABSTRACT

Manual blood pressure (BP) is no longer the preferred method for office BP measurement. Problems with the accuracy of its readings, white coat effect and concerns about mercury as an environmental hazard contributed to its decline. Instead, recent guidelines now favour validated, electronic sphygmomanometers which record BP using the oscillometric technique. These devices have several advantages, including taking multiple readings at standard intervals, such as every one minute, with a minimum of human involvement. Basic requirements for BP measurement such as a proper size cuff, standard position of the patient and no conversation are still important. No longer is it necessary to rely on the auscultatory skills of clinic staff, proper cuff deflation rate and accurate transcription of readings to the medical records, if the oscillometric devices are connected directly to electronic medical records. A special type of oscillometric BP reading is 'automated office BP' (AOBP) measurement. The principal features of AOBP include several readings recorded with a fully automated device with the patient resting quietly and alone without any conversation, which is a major cause of the white coat effect when clinic staff is present. AOBP is more accurate than manual or ordinary oscillometric BP in routine office practice and, unlike readings recorded by clinic staff, it does not require an additional period of rest before the first BP reading. Thus, the optimum method for recording office BP in the 21st century is with an automated oscillometric sphygmomanometer, preferably with the patient being alone.

Key words: blood pressure measurement, hypertension, sphygmomanometers

The era of the mercury sphygmomanometer

For the first 100 years of blood pressure (BP) measurement, the mercury sphygmomanometer was the standard device used to record BP. As of 1999, evidence-based guidelines[1] began to recognize the advantages of readings recorded outside of the clinic setting, including 24-hour ambulatory BP monitoring (ABPM) and home BP self-measurement by the patient. Around this same time, the limitations of office BP began to attract more attention.

Standard guidelines for proper office BP measurement include a 5 minute rest period before the first reading, use of a proper size cuff, having the patient seated with the back supported and feet on the floor, multiple readings in the presence of arrhythmias such as atrial fibrillation and, especially, no conversation between the clinic staff and the patient. With the advent of ABPM, it soon became evident that BP readings in the clinic were much higher (on average 15/8 mmHg) than the awake ambulatory BP and about 10/7 mmHg higher than a manual BP recorded in a research study using standard guidelines[2]. The initial response was to try and improve BP measurement technique in the clinic by increased promotion of the guidelines and the use of oscillometric sphygmomanometers, often modified from recorders being used for BP self-measurement in the home.

The impact of the disappearance of mercury on manual office BP

Two developments had a major impact of office BP.

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The first was the increasing evidence that ABPM and home BP were better methods for diagnosing hypertension in clinical practice. However, ABPM was relatively expensive and the costs were not covered by most government health plans. Home BP was more popular with patients, but physicians frequently attributed differences between home and clinic readings to poor measurement technique on the part of the patient. Reporting bias, with patients not transmitting their actual readings accurately to the clinic staff, was also a concern[3]. The net result was that physicians tended to believe their own clinic readings when the BP reported by the patient was different, thus limiting the usefulness of home BP for patient management.

The second development was the recognition that the mercury contained in sphygmomanometers represented an environmental hazard. Edicts from the European Community and United Nations subsequently led to a ban on the use of mercury in the work-place, including hospitals and clinics. Although the mercury sphygmomanometer is probably still in widespread use in doctors' offices, it is gradually being replaced by other devices. For many, the aneroid sphygmomanometer was the obvious alternative. It had been used for decades and was readily available. However, these devices have a major shortcoming, in that they record BP using mechanical components which often lose their calibration, making the readings inaccurate with repeated use. The manufacturers responded by recommending re-calibration of these sphygmomanometers at regular intervals, such as every 6 months. However, several surveys in clinical practice have reported that a high percentage of aneroid devices were inaccurate, with the apparent cause being the failure to perform re-calibration.

The need for a replacement for the mercury sphygmomanometer led to the development of hybrid devices which used an electronic pressure gauge instead of a mercury column to measure BP. Examples of hybrid devices include the Accoson Greenlight 300, Heine Gamma G7, Nissei DM-3000, Rossamax Mandaus and Welch-Allyn Maxi Stabil 3. Although validated for accuracy, these devices have not been widely used in clinical practice or in research studies.

Office BP measurement with oscillometric sphygmomanometers

Manual BP measurement with aneroid and other non-mercury sphygmomanometers still required the involvement of clinic staff to correctly auscultate the Korotkoff sounds and to accurately transcribe the readings. Oscillometric devices presented an attractive alternative, in that BP readings could be obtained with less opportunity for human error. Over time, validated oscillometric devices became available with several useful features, such as automatic recording of multiple readings with a single activation, storage of readings and automatic averaging of the measurements. These sphygmomanometers had several advantages over the mercury and aneroid devices. They did not require auscultation, two or three readings could be recorded automatically at a standard time interval such as one minute, the average reading could be calculated automatically and readings could be transmitted directly to electronic medical records, which precluded reporting bias and rounding off the BP to the nearest zero value, such as 140/90 mmHg.

It should be noted that replacing manual BP with electronic devices requires adherence to the standard guidelines for office BP measurement. These oscillometric devices may solve the problem of single auscultatory BP readings in the clinic, but they still require staff to ensure that the patient rests for five minutes before the first BP and that there is no conversation immediately before or during the actual measurement of the BP, both factors being major contributors to higher office BP readings versus ambulatory or home BP, otherwise known as the 'white coat effect'.

The availability of oscillometric sphygmomanometers which automatically record BP led investigators to examine the possible advantages of having patients record their own BP in the clinic while resting alone, by comparing the readings to either the awake ambulatory BP or to home BP. The mean self-measured systolic/diastolic BP in hypertensive patients while alone in the clinic in 4 studies[4-7] was on average 7.5/4.0 mmHg higher than the out-of-office BP. Thus, involving patients in the BP measurement process did not result in readings comparable to ambulatory BP or home BP, but instead produced readings which were similar to manual BP, as performed according to guidelines in other research studies[2].

Current status of conventional office BP measurement

The prohibition of mercury in the health-care setting has clearly accelerated the transition away from manual BP measurement. No longer can advocates of traditional measurement of clinic BP justify using the mercury sphygmomanometer because it was used in the vast majority of landmark trials in hypertension. The aneroid device was rarely used in research studies and concerns about re-calibration have limited its

prominence in current hypertension guidelines. Moreover, there is abundant evidence that manual BP in routine clinical practice is about 15/8 mmHg higher than the awake ambulatory BP[2]. In comparison, a manual BP performed in a research study with close adherence to the guidelines is only 5/5 mmHg higher than the out-of-office BP, with comparative thresholds for diagnosing hypertension being 140/90 mmHg versus 135/85 mmHg, respectively.

One might expect that an oscillometric office BP recorded in clinical practice would be less subject to a white coat effect, with mean readings closer to the awake ambulatory BP. However, data from the Spanish ABPM Registry[8] reported that a mean of two oscillometric office BP readings in primary care in over 27,000 hypertensive patients was 25/11 mmHg higher than the awake ambulatory BP. Thus, simply replacing manual BP with an oscillometric device may not eliminate the white coat effect associated with out-of-office BP.

Automated office BP measurement

In the past decade, a new approach[9] to office BP measurement has appeared – automated office BP (AOBP). The premise which led to this technique is that BP readings in the clinic are higher when doctors or nurses are present with the patient. Several factors are likely involved including the opportunity for conversation with the patient and increased anxiety on the part of patients when in the presence of clinic staff. Thus, AOBP simply requires that readings be taken with a fully automated oscillometric sphygmomanometer which records multiple BP measurements with the patient resting alone in a quiet place. The device should not require activation by the patient which could increase the readings and there should preferably be a brief interval of at least one minute before the first reading is taken to allow time for staff to leave the patient alone.

In 2002, 2 devices capable of recording AOBP became available, the Omron 907 and the BPTRU. In the first study[10] using the AOBP method, we found that a routine office BP of 174/92 mmHg was reduced to an AOBP of 155/88 mmHg. Subsequent studies in patients with milder hypertension have reported that the mean AOBP was on average 15/8 mmHg lower than a routine office BP and was similar to the mean awake ambulatory BP[2,9]. On the basis of mean BP values, AOBP seems to eliminate the white coat effect, although some individual patients will still have readings which are higher than the awake ambulatory BP. AOBP readings have other advantages over routine clinic BP[2], including a stronger correlation with ambulatory BP readings and significantly less digit preference (rounding off readings to the nearest zero value).

AOBP is also a better predictor of intermediate measures of target organ damage than conventional clinic BP. In one study[11] involving 176 normal subjects, the intima-media thickness of the carotid artery correlated significantly with systolic/diastolic AOBP ($p=0.02/p=0.007$), but not with manual BP readings. In another study[12] involving 90 hypertensive patients, awake ambulatory BP and AOBP both correlated significantly ($r=0.37$) with left ventricular mass, whereas the correlation with office BP was only $r=0.12$.

AOBP and cardiovascular outcomes

There are also longitudinal cardiovascular outcome studies to support the use of AOBP in clinical practice. The only screening study in hypertension to demonstrate a reduction in cardiovascular events, the Cardiovascular Health Awareness Program (CHAP) used AOBP as the method for measuring BP[13]. A sub-set of 3,267 participants in CHAP, aged >65 years and untreated for hypertension at baseline, was followed for a mean of 4.9 years[14]. There was a progressive increase in cardiovascular events starting at a BP of 110/60 mmHg and becoming statistically significant at a threshold of 135/80 mmHg. In 6,183 participants in CHAP who were treated for hypertension at baseline[15], the lowest rate of cardiovascular events during 4.6 years of follow-up was seen at a mean BP of 110-119 mmHg, which is consistent with the benefits of treating hypertension to a systolic AOBP target of <120 mmHg in the Systolic BP Intervention Trial (SPRINT[16]). Thus, not only is AOBP a more accurate technique for obtaining a measure of BP in the clinic setting, but it also is similar to mean awake ambulatory BP in its relationship to clinical cardiovascular outcomes[17,18].

The feasibility of introducing AOBP into clinical practice

Critics of AOBP have expressed concern about its feasibility for routine clinical practice in that it requires a quiet place for the patient to rest for 4-7 minutes without clinic staff being present. The best evidence demonstrating that AOBP is indeed feasible comes from a survey of primary care physicians in Canada[19] where AOBP was first introduced into the guidelines for the diagnosis of hypertension in 2011. In the survey, over 50% of physicians re-

ported using AOBP in their practice, with 39% using it for hypertension screening. Overall, only 21% of physicians were using manual BP measurement to diagnose hypertension.

When considered not to be feasible, AOBP is usually being compared to a single BP reading recorded without the 5 minutes of antecedent rest required by standardized measurement guidelines. If doctors are to perform office BP properly, there should be a quiet place for the patient to rest, regardless of how BP is measured. The only issue seems to be having clinic staff present during readings, called 'attended' AOBP. There is some evidence[20] that a BP recorded in a research study using an oscillometric sphygmomanometer with strict adherence to standard measurement guidelines is similar to AOBP. Although this finding may be valid, nobody has yet demonstrated that such readings will be performed in this way in routine clinical practice[20]. Moreover, nobody has given a reason why a doctor or nurse needs to be present when BP is being recorded with an automated sphygmomanometer. Their presence may be problematic in that is may increase anxiety in some patients and provides an opportunity for conversation, both of which can increase BP.

Conclusions

When it comes to screening patients in the office for hypertension, AOBP readings provide the best measure of an individual's BP status. Patients with suspected hypertension should then undergo 24-hour ABPM or, if unavailable, seven days of home BP readings with accurate transmission of the results to clinic staff. If the only automated sphygmomanometer available requires activation by the patient, then several readings should be recorded, preferably with the patient alone, with the results being comparable to a manual BP recorded in a research setting in accordance with standard guidelines. Manual BP measurement by doctors or nurses is no longer the preferred method for clinic BP.

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