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Measurement of blood pressure: New developments and challenges

Automated blood pressure measurement and out-of-office BP measurement can both play a part in obtaining the accurate and reliable readings needed for appropriate diagnosis and treatment of hypertension.

ABSTRACT: High blood pressure is a major, modifiable risk factor for heart attack, stroke, and renal failure. One in five Canadians have high blood pressure. Blood pressure measurement is one of the most commonly performed medical tests. Accurate BP measurement is the foundation of optimal diagnosis and treatment of hypertension. Although the last few years have witnessed a proliferation of different techniques, modalities, and devices all designed to measure blood pressure, concerns remain about the optimal strategies to measure it accurately and reliably. Current modalities include manual office BP measurement, automated office BP measurement, 24-hour ambulatory BP measurement, and home BP measurement. It is important to appreciate the advantages and disadvantages of different modalities and strategies including their accuracy and reliability, cost, degree of intrusiveness, level and type of training required, anticipated compliance with recommended techniques, scalability, and time and resources required to conduct the measurement.

High blood pressure (BP) or hypertension is a key factor in the development of atherosclerosis, the main cause of vascular and cerebrovascular diseases: ischemic heart disease, myocardial infarction, congestive heart failure, and stroke. Elevated blood pressure is also linked causally to kidney failure and dementia.[1,2] Healthy lifestyle choices coupled with early detection and optimal treatment to control high blood pressure can substantially reduce the risk of developing these problems.

The recent Canadian Health Measures Survey estimated that one in five Canadian adults have hypertension and another 20% have prehypertension.[3] The risk of developing hypertension increases with age: the residual lifetime risk of developing hypertension for middle-aged individuals is estimated to be 90%.[4]

The global burden of hypertension-related disease is substantial: in 2001 over 54% of strokes, 47% of ischemic heart disease, and 13.5% of all deaths worldwide could be attributed to high BP.[5] Also in 2001, worldwide direct medical costs related to elevated blood pressure were estimated at US$370 billion—about 10% of the health care expenditures in developed countries.[6] In Canada the cost of hypertension-related care—physician visits, laboratory tests, and medications—was estimated to be almost $2.4 billion in 2007.[7]

Blood pressure measurement

Blood pressure measurement is one of the most commonly performed medical tests in the world. It is a critical measure, providing information that is used for many purposes, including determining whether a patient is at increased risk for developing vascular disease because of elevated blood pressure. Accurate BP measurement is the foundation of optimal diagnosis and treatment of hypertension. BP measurement is increasingly performed in many settings, both inside and outside the clinic or office. When a clinician is attempting to diagnose hypertension, the most important consideration is the BP level. It is critical

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for the clinician to be able to rely on the measurement, and to be comfortable that the BP readings done in different settings are accurate, comparable, and complementary. Unfortunately, because BP measurement is performed in many settings, often using different methods and devices, BP results are often difficult to compare between readings and settings.

Although in the last few years there has been a proliferation of different techniques, modalities, and devices designed to measure blood pressure, concerns remain about the optimal strategies to measure accurately and reliably something as intrinsically variable as blood pressure.

Manual office blood pressure measurement

Blood pressure measurement in most clinical settings is commonly performed using an air-filled cuff around the patient's arm and a manual auscultatory technique. The clinician places a stethoscope over the brachial artery and listens as the cuff deflates while observing a mercury sphygmomanometer. This method, developed in 1896 by Riva-Rocci, has not changed appreciably since that time, with the only improvements being the auscultatory method developed by Sergei Korotkoff during the Russo-Japanese War (1904–1905), and the use of Velcro to fasten the cuff.

Manual blood pressure measurements with a calibrated sphygmomanometer can be very accurate if performed properly. There is, however, widespread concern about the quality and accuracy of manual blood pressure measurement in clinical settings.[8,9] There is growing evidence that because of poor measurement techniques that include the use of uncalibrated sphygmomanometers, inappropriate cuff size, zero-digit bias, patient-clinician interaction during measurement, and failure to reduce patient anxiety, the BP readings obtained in routine clinical practice are often imprecise and inconsistent.[10-15] As a result, manual measurement of BP in office settings frequently leads to overestimation of BP values (the white-coat effect) and underestimation of true elevated BP (masked hypertension). Needless to say, these inaccurate readings can result in misdiagnosis and lead to either unnecessary drug therapy or lack of necessary treatment. Following proper technique, including a period of rest before the first measurement, is therefore critical if manual office BP readings are to be used for diagnosis or therapeutic decisions.

Automated office blood pressure measurement

The recent development of a fully automated sphygmomanometer that records multiple BP measurements with the patient resting alone in a quiet room offers a possible solution to the problem of office-induced hypertension and inaccurate manual readings.[9,15] Automated office blood pressure (AOBP) measurement was developed specifically to standardize BP measurement in the office or clinic setting. It is performed using an electronic device that operates by the oscillometric method, which has been studied extensively for over 40 years. It offers clinicians the best means of standardizing BP measurements wherever they are taken—in the clinic, home, pharmacy, or during ambulation. Many of these devices, although not all of them, have been validated according to one or more internationally recognized hypertension protocols, and their measurements compare well with each other.

AOBP measurement has been shown to provide clinicians with two diagnostic requirements that traditional BP measurement cannot provide in the office or clinic setting: accuracy and clinical relevance. To do this, however, it is important to use AOBP devices in a strictly prescribed manner so that the results are reproducible and can thus be used with the knowledge that both of these clinical requirements are met.

The standardized method for AOBP measurement is to place the patient in the sitting position, with the back supported and the legs resting uncrossed on the ground or on a foot stool. A properly fitted cuff is placed on the upper arm, which should rest on a chair arm or table so that the patient's cuffed upper arm is at heart level. Only cuffs supplied by the manufacturer should be used, since the device components are calibrated as a unit. The device should be set to take multiple measurements automatically at 1- or 2-minute intervals. New research has established that similar readings are obtained at both the 1-minute and the 2-minute mark, allowing for use of the shorter interval if desired.[16] The clinician should observe the first reading to ensure that a valid BP measurement is obtained, then leave the patient alone in the room to complete the rest of the measurements without disturbance or distraction. After instructions are given to the patient, no conversation should take place. The average reading shown on the device should be recorded and used for diagnostic or therapeutic purposes.

The average BP from multiple measurements obtained using an AOBP device in the office or clinic setting has been shown in several studies to be very close to that obtained from the current gold standard for measuring BP: the average daytime ambulatory BP, a measure shown to correlate well with cardiovascular outcomes such as acute myocardial infarction and cerebrovascular events.

AOBP measurement has been shown to virtually eliminate the white-coat effect. For all of these reasons, AOBP measurement is superior to routine office BP measurement. Studies are currently underway to establish how well AOBP readings correlate directly with clinical outcomes.

There are currently three commonly used AOBP measurement devices: BpTRU, Microlife WatchBP Office, and Omron 907. The BpTRU, when used in the automatic mode, will take six BP readings and automatically discard the first before providing an average of the remaining five readings. The Microlife and Omron devices take two or three readings and average them. All these devices sell for approximately $1000.

AOBP measurement has been used in the pharmacy as well as the office or clinic setting. Community-based studies in both Ontario and Alberta have used BpTRU in pharmacies to help patients obtain accurate BP readings.[17,18] In the large community cluster randomized trial in Ontario, 20 of 39 mid-sized communities took part in the Cardiovascular Hypertension Awareness Program (CHAP), which included use of BpTRU. When the communities were compared, CHAP was associated with a 9% relative reduction in annual CVD hospital admissions (rate ratio 0.91; 95% CI 0.86–0.97, P = .002) or 3.02 fewer admissions per 1000 people 65 years and older.[18] These results suggest that out-of-office BP measurements used to augment in-office data have the potential to improve hypertension detection and management by reducing both observer effects and the effect of the clinical setting.[19-22]

The Canadian Hypertension Education Program (CHEP) has recognized that automated office blood pressure devices are being used more frequently and has provided guidance on their use. Evidence has been found to support the following recommendations:

- Automated office blood pressure measurements can be used in the assessment of office blood pressure (Grade D).
- When used under proper conditions, automated office SBP of 135 mm Hg or higher or DBP values of 85 mm Hg or higher should be considered analogous to mean awake ambulatory SBP of 135 mm Hg or higher and DBP of 85 mm Hg or higher, repectively (Grade D). (The full 2012 CHEP recommendations for treating and controlling hypertension are available at http://hypertension.ca/chep-recommendations.)

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Ambulatory blood pressure measurement

The current gold standard for BP measurement is 24-hour ambulatory blood pressure measurement or monitoring (ABPM). This is performed by having the patient wear a blood pressure cuff attached to a pump and recording device for 24 hours. The advantage of this technique is that it can take many readings over the night and day while the patient sleeps and then undertakes relatively normal activities.[23] The cuff needs to be positioned correctly and kept dry, so strenuous activity is usually not possible. The ABPM device downloads data to a computer and permits a review of the 24-hour measurements and trends, including the usual BP decline (dip) at night. There are several models available, all of which cost in the $2000 range. Expenses in addition to the device itself include spare chargers and a connection to a computer with the device software installed. Another consideration is the time a health professional must spend to put the device on the patient and check it, and to take the device off and download the data to the computer.

Considering the costs in time and money,[24] it is important to review the need to perform ABPM. Ambulatory measurement is indicated where the blood pressure variation between sequential conventional office readings is large or the difference between home and office readings is large, or when the BP is not falling in response to treatment.[25] ABPM overcomes a lot of the variation in conventional readings caused by, for example, poor maintenance of the sphygmomanometer or

lack of time to measure BP in a quiet environment with the patient rested. The number of readings with ABPM gives an added value over and above that of even the most precise office measurement. This combination of many accurate readings results in a better prediction of mortality and morbidity associated with hypertension.[26] ABPM is also useful in the detection of white-coat hypertension. In primary care, white-coat hypertension carries a lower long-term risk than hypertension diagnosed using ABPM. In a 7-year follow-up study of 5918 patients in primary care, the unadjusted rate for all-cause mortality in patients with white-coat hypertension (25.3% of the population studied) was 6.7 (95% CI 5.3–8.5) compared with 8.8 (95% CI 7.6–10.1) for patients with uncontrolled hypertension (n = 2948).[27] A recent meta-analysis of nearly 8000 subjects shows no difference in outcome between those with white-coat hypertension and those who are normotensive.[28] The impact of a method that can determine which patients do not actually need treatment (perhaps as many as one-quarter of patients labeled as hypertensive) is an important part of the cost equation.[29]

Home BP measurement

Among the respondents to the 2009 Survey on Living with Chronic Diseases in Canada who reported diagnosis of hypertension by a health professional, almost half (45.9%) indicated that they monitor their own blood pressure at home. However, fewer than one in six Canadian adults diagnosed with hypertension monitor their own blood pressure at home regularly following health professional instruction and communicate results to a health professional.[30] This is despite the fact that monitoring BP at home, with proper use of approved devices, is widely recommended[31] and supported by evidence demonstrating potential for improved control of hypertension. A systematic review of the literature on home BP measurement concluded that it yields lower values than office measurement, with differences in systolic BP that increase with age and the level of BP measured in-office.[32] Home monitoring also correlates better with target organ damage and cardiovascular mortality than office measurement, enables prediction of sustained hypertension in patients with borderline hypertension, identifies normotensive patients with greater certainty, and can better assess drug efficacy.[32] Blood pressure monitors can be purchased in most pharmacies and devices endorsed by Hypertension Canada are listed on the organization's website (http://hypertension.ca/devices-endorsed-by-hypertension-canada-dp1).

Summary

With several new technologies available for measuring a patient's blood pressure, it is no longer acceptable to rely simply on a reading obtained from a hastily performed manual office BP measurement when making critical decisions related to BP. Blood pressure varies through the day and can change with the psychological state of the patient, the location of the assessment, the observer, and the measuring device. Thus, misdiagnosis can occur and lead to white-coat hypertension and masked hypertension, and these errors can in turn lead to overdiagnosis and underdiagnosis as well as errors in starting or withholding treatment. In general, more readings are better than fewer readings to detect hypertension and optimize treatment and monitoring of blood pressure. Because accurate and reliable measurement of BP is fundamental for appropriate diagnosis and treatment of hypertension,[5] it is important to appreciate the pros and cons of different modalities and strategies. Additional considerations involved in selecting an approach to blood pressure measurement include cost, level and type of training required, degree of intrusiveness, anticipated compliance with recommended techniques, scalability, and the time required to conduct the measurement.

Competing interests

None declared.

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