# I. Accurate Measurement of Blood Pressure

## DIAGNOSIS AND ASSESSMENT

http://recommendations.hypertension.ca/diagnosis-assessment/measuring-blood-pressure/

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### Recommendations

1. Health care professionals who have been specifically trained to measure BP accurately should assess BP in all adult patients at all appropriate visits to determine cardiovascular risk and monitor antihypertensive treatment (Grade D).
2. Use of standardized measurement techniques and validated equipment for all methods (office blood pressure measurement (OBPM), automated office blood pressure (AOBP), home blood pressure measurement (HBPM) and ambulatory blood pressure measurement (ABPM) is recommended (Grade D; see Supplemental Table S2, Section VII. Home BP Monitoring, Section VIII. Ambulatory BP Monitoring and Table 1).
3. Four approaches can be used to assess BP (see text for definitions):
    i. Office BP measurement (OBPM): Measurement using electronic (oscillometric) upper arm devices is preferred over auscultation (Grade C) (unless specified otherwise, henceforth OBPM refers to electronic (oscillometric) measurement). When using mean OBPM, an SBP ≥140 mm Hg or a DBP ≥90 mm Hg is high, and an SBP between 130-139 mm Hg and/or a DBP between 85 and 89 mm Hg is high-normal (Grade C).
    ii. Automated Office Blood Pressure Measurement (AOBP): AOBP is the preferred method of performing in-office BP measurement (Grade D; new recommendation). When using AOBP (see the section on Recommended Technique for Automated Office Blood Pressure in Supplemental Table S2), a displayed mean SBP ≥135 mm Hg or DBP ≥85 mm Hg is high (Grade D).

iii. Ambulatory BP Measurement (ABPM): Using ABPM (see Recommendations in Section VIII, ABPM), patients can be diagnosed as hypertensive if the mean awake SBP is ≥135 mm Hg or the DBP is ≥85 mm Hg or if the mean 24-hour SBP is ≥130 mm Hg or the DBP is ≥80 mm Hg (Grade C).
iv. Home BP monitoring (HBPM): (see Recommendations in Section VII, HBPM) Patients can be diagnosed as hypertensive if the mean SBP is ≥135 mm Hg or the DBP is ≥85 mm Hg (Grade C). If the OBPM is high and the mean home BP is <135/85 mm Hg, it is advisable to either repeat home monitoring to confirm the home BP is <135/85 mm Hg or perform 24-hour ABPM to confirm that the mean 24-hour ABPM is <130/80 mm Hg and the mean awake ABPM is <135/85 mm Hg before diagnosing white coat hypertension (Grade D).

## Background

**1. Health care professionals who have been specifically trained to measure BP accurately should assess BP in all adult patients at all appropriate visits to determine cardiovascular risk and monitor antihypertensive treatment (Grade D).**

Direct evidence supporting the merits of BP screening is scarce; thus, this recommendation is largely based upon expert consensus and specifically, the reality that if BP screening is not performed, hypertension cases will remain undetected.

Blood pressure screening frequency and timing may vary between patients and is left to the discretion of each practitioner. Periodic health exams, visits for assessment of other cardiovascular risk factors, urgent office visits for neurological or cardiovascular related issues, medication renewal visits are examples of medical visits considered appropriate for blood pressure measurement (1). Hypertension-related complications are more common in older patients, in those with multiple cardiovascular risk factors, and in patients with pre-existing cardiovascular disease; furthermore, treatment-related absolute risk reductions are greater in high-risk subgroups (2-4). Accordingly, the frequency of screening may increase depending on the clinical situation.

Accurate assessment of blood pressure is necessary for proper diagnosis, precise cardiovascular risk assessment, to gauge the necessity for intervention, and to monitor treatment effect. Accurate blood pressure measurement requires standardized measurement techniques, calibrated equipment and valid interpretation of readings (1,5-8) The importance of accurate measurement cannot be overstated – it is important to avoid both false positive and false negative results. A recent Canadian cluster randomized controlled trial demonstrated that a comprehensive cardiovascular risk assessment and education program implemented in community pharmacies reduced cardiovascular mortality compared to no intervention (9). BP assessment was an important component of the risk assessment performed in this trial.

2. Use of standardized measurement techniques and validated equipment for all methods (office blood pressure measurement (OBPM), automated office blood pressure (AOBP), home blood pressure measurement (HBPM) and ambulatory blood pressure measurement (ABPM) is recommended (Grade D; see Supplemental Table S2, Section VII. Home BP Monitoring, Section VIII. Ambulatory BP Monitoring and Table 1).

Studies have repeatedly demonstrated that blood pressure is not carefully assessed in clinical practice, especially when measured manually using an auscultatory technique (10-15) Summaries of standardized techniques for ambulatory blood pressure measurement (ABPM; Table 1), home blood pressure measurement (HBPM; Section VII), automated office (AOBP; Table S2) and manual office (MOBP; Table S2) have been provided.

Deviations from standardized blood pressure measurement techniques can introduce inaccuracy and lead to misclassification of cardiovascular risk (5-7,11,12,14-20). For example, measuring blood pressure with the arm positioned below the level of the heart can lead to blood pressure overestimation of 7-10/8-11 mm Hg, compared with positioning the arm correctly at the level of the atria (21-25). Leg crossing during blood pressure measurements may increase values by 8-10/4-5 mm Hg (26-30). Examples of other patient-related factors that affect the accuracy of blood pressure measurement include talking during the procedure (+17/+13 mm Hg) and acute exposure to cold (+11/+8 mm Hg). Additional provider-related errors include failure to support the arm (+2/+2 mm Hg), using an inappropriate cuff size (+8/+8 mm Hg if the cuff is too small) (31-33), and terminal digit preference (rounding up or down to the nearest 0 or 5) (6).

**3. Four approaches can be used to assess BP (see text for definitions):**

**I. OFFICE BP MEASUREMENT (OBPM): MEASUREMENT USING ELECTRONIC (OSCILLOMETRIC) UPPER ARM DEVICES IS PREFERRED OVER AUSCULTATION (GRADE C) (UNLESS SPECIFIED OTHERWISE, HENCEFORTH OBPM REFERS TO ELECTRONIC (OSCILLOMETRIC) MEASUREMENT). WHEN USING MEAN OBPM, AN SBP ≥140 MM HG OR A DBP ≥90 MM HG IS HIGH, AND AN SBP BETWEEN 130-139 MM HG AND/OR A DBP BETWEEN 85 AND 89 MM HG IS HIGH-NORMAL (GRADE C).**

Over the past century, auscultation has been the predominant blood pressure measurement method. If auscultatory blood pressure is performed properly (i.e., using standardized methodology), it correlates well with ambulatory measurements and can predict target organ changes (34-36). However, 'real world' routine office auscultatory measurement, when performed by both in nurses and physicians, is consistently inaccurate because standardized methodology is simply not followed (5,13-15,18,20,37-39). The BP obtained in routine clinical practice is on average 9/6 mm Hg higher than standardized measurements (40,41). Unfortunately repeated educational programs to improve blood pressure measurement do not produce sustainable improvements in technique (14,42-47). The widespread removal of mercury from clinics and

hospitals has created an additional source of error, as replacement anaeroid devices commonly used for auscultation are inaccurate unless regularly calibrated (which is not often done).

For these reasons, the Task Force strongly encourages the use of validated electronic digital oscillometric devices. These devices are pre-programmed to take either single measurements or an automated series of measurements with averaging of the results. Electronic oscillometric devices minimize or eliminate many auscultation-induced errors, including those related to provider hearing deficits, terminal digit preference (rounding the reading to 0 or 5) and rapid deflation (48,49). Many devices for both clinical and public use have been found to be accurate and reproducible when compared to research-quality OBP (www.dableducational.com).

It is important to note that, although OBPM is often used for initially assessing BP in a given individual, the diagnosis should be confirmed by performing out-of-office measurement (if possible). Further details are provided in the recommendations that follow.

Atrial fibrillation poses unique challenges in terms of blood pressure measurement because it leads to random fluctuations in stroke volume and pulse pressure, which affects the accuracy of both auscultation and oscillometric measurement (5,50). For these reasons, performing multiple measurements to obtain consistent results is important in patients with atrial fibrillation. Notably, newer oscillometric devices have produced more accurate readings in patients with atrial fibrillation (51-53).

## II. AUTOMATED OFFICE BLOOD PRESSURE MEASUREMENT (AOBP): AOBP IS THE PREFERRED METHOD OF PERFORMING IN-OFFICE BP MEASUREMENT (GRADE D; NEW RECOMMENDATION). WHEN USING AOBP (SEE THE SECTION ON RECOMMENDED TECHNIQUE FOR AUTOMATED OFFICE BLOOD PRESSURE IN SUPPLEMENTAL TABLE S2), A DISPLAYED MEAN SBP ≥135 MM HG OR DBP ≥85 MM HG IS HIGH (GRADE D).

Certain fully automated BP measuring devices intended for clinic use are capable of taking repeated BP measurements when a patient is alone in the examining room (54,55). Using repeat measure devices in this manner has been referred to as automated office BP (AOBP) measurement. AOBP is a specific type of OBPM designed to overcome some of the limitations of OBPM. Multiple (3-6, depending on the device) pre-programmed measurements, usually spaced one minute apart over 4-7 minutes, are taken while the patient is alone in a quiet room. Recommendations for measurement standardization related to patient position and proper cuff size also apply to AOBP.

AOBP provides a more standardized assessment of blood pressure compared to routine manual office measurement and is more reproducible than manual office measurement. Because the patient is left alone, error introduced by conversing with the patient during the measurement process is eliminated (56,57). Importantly, compared to manual office measurements, AOBP has repeatedly been demonstrated to correlate more closely with daytime ABPM (41,58-62).

Furthermore, use of AOBP reduces office-induced blood pressure increases (i.e., white coat effect) and is associated with a lower prevalence of masked hypertension (58,61). On the basis of the above evidence the CHEP Recommendations Task Force endorsed the use of AOBP for office blood pressure measurement in 2011 (63).

Several studies (40,60,61) have shown that mean AOBP readings are comparable to daytime ambulatory BP readings, therefore a mean AOBP of SBP ≥135 mm Hg or DBP ≥85 mm Hg is considered high.

There are no studies that directly relate AOBP readings to the occurrence of cardiovascular events. Three cross-sectional studies demonstrating high correlations between AOBP levels and surrogate measures of end-organ damage (left ventricular mass index, urinary albumin excretion, and carotid intima-medial thickness) have been published (64-66). Further research is required to determine whether AOBP measurements can predict target organ damage and cardiovascular events better than manual office readings. For this reason, high AOBP readings should be confirmed using out-of-office measurement before making a diagnosis of hypertension.

Several AOBP devices have been independently validated for clinical accuracy including the BpTRU automatic BP monitor (BpTRU Medical Devices, Canada – the most commonly used device in Canada), the BPM-100 electronic oscillometric office BP monitor, the Omron office digital BP HEM-907 monitor (Omron Canada Inc, Canada), and the Microlife WatchBP Office professional device (Microlife AG Swiss Corporation, Switzerland) (60,67-69).

**III. AMBULATORY BP MEASUREMENT (ABPM): USING ABPM (SEE RECOMMENDATIONS IN SECTION VIII, ABPM), PATIENTS CAN BE DIAGNOSED AS HYPERTENSIVE IF THE MEAN AWAKE SBP IS ≥135 MM HG OR THE DBP IS ≥85 MM HG OR IF THE MEAN 24-HOUR SBP IS ≥130 MM HG OR THE DBP IS ≥80 MM HG (GRADE C).**

These widely accepted 24-hour ambulatory blood pressure thresholds have been derived from prognostic studies examining cardiovascular morbidity and mortality endpoints (70-75).

**IV. HOME BP MONITORING (HBPM): (SEE RECOMMENDATIONS IN SECTION VII, HBPM) PATIENTS CAN BE DIAGNOSED AS HYPERTENSIVE IF THE MEAN SBP IS ≥135 MM HG OR THE DBP IS ≥85 MM HG (GRADE C). IF THE OBPM IS HIGH AND THE MEAN HOME BP IS <135/85 MM HG, IT IS ADVISABLE TO EITHER REPEAT HOME MONITORING TO CONFIRM THE HOME BP IS <135/85 MM HG OR PERFORM 24-HOUR ABPM TO CONFIRM THAT THE MEAN 24-HOUR ABPM IS <130/80 MM HG AND THE MEAN AWAKE ABPM IS <135/85 MM HG BEFORE DIAGNOSING WHITE COAT HYPERTENSION (GRADE D).**

The threshold above which home/self BP values should be considered elevated is 135/85 mm Hg. This is supported by prognostic studies showing an increased risk of cardiovascular events above or near this threshold (76-84).

The need to further assess patients when a home BP measurement is less than 135/85 mm Hg (and white coat effect is suspected) is based on the Treatment of Hypertension Based on Home or Office Blood Pressure (THOP) trial, where home/self BP monitoring was specific (89%) but not sensitive (68%) in its ability to detect white coat hypertension (85-87). Other studies also support this recommendation. In particular, this recommendation applies when the home BP is borderline normal. Further assessment can be done by either repeating home BP or performing ABPM.

**TABLE 1. STANDARDIZED PROTOCOL FOR AMBULATORY BP MONITORING (GRADE D)**

- The appropriately sized cuff should be applied to the nondominant arm unless the SBP difference between arms is > 10 mm Hg, in which case the arm with the highest value obtained should be used
- The device should be set to record for a duration of at least 24 hours with the measurement frequency set at 20 to 30-minute intervals during the day and 30-60 minutes at night
- A patient-reported diary to define daytime (awake), nighttime (sleep), activities, symptoms, and medication administration is useful for study interpretation
- Daytime and nighttime should preferentially be defined using the patient's diary. Alternatively, predefined thresholds can be used (e.g., 0800-2200 hours for awake and 2200-0800 hours for nighttime)
- The ambulatory BP monitoring report should include all of the individual BP readings (numerically and graphically), the percentage of successful readings, the averages for each time frame (daytime, nighttime, 24 hours) and the "dipping" percentage (the percentage the average BP changed from daytime to nighttime)
- Criteria for a successful ambulatory BP monitoring study are:
    - At least 70% of the readings are successful, and
    - At least 20 daytime readings and 7 nighttime readings are successful

BP, blood pressure; SBP, systolic blood pressure.

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