Measurement of systemic arterial blood pressure

Medición de la presión arterial sistémica

Luis Alcocer Díaz-Barreiro, MD,* José Manuel Enciso-Muñoz, MD‡

ABSTRACT

Blood pressure levels are the looking glass into the complex world of high blood pressure (HBP). HBP is diagnosed with blood pressure measurements, which is also helpful for classification, risk management, need for treatment initiation and adjustment and establishing management goals. In this paper, we discuss the validity and usefulness of methods to evaluate blood pressure, with particular focus on casual measurement using mercury sphygmomanometer in-office automated measurement, Ambulatory Blood Pressure Measurement, Home Measurement of Blood Pressure, and measurement of central blood pressure. We will also discuss the influence of this measurement on interpretation and the role of white coat HBP and masked HBP in influencing blood pressure measurements.

RESUMEN

Los niveles de presión arterial son el espejo del complejo mundo de la hipertensión arterial (HTA). La HTA se diagnostica con mediciones de la presión arterial, que también son útiles para la clasificación, gestión del riesgo, necesidad de iniciar y ajustar el tratamiento y el establecimiento de objetivos de gestión. En este artículo se analiza la validez y la utilidad de los métodos para evaluar la presión arterial, con especial atención a la medición casual con esfigmomanómetro de mercurio en el consultorio, la medición ambulatoria de la presión arterial, medición domiciliaria de la presión arterial y la medición de la presión arterial central. También discutiremos la influencia de esta medición en la interpretación y el papel de la HTA de bata blanca y la HTA enmascarada en la influencia de las mediciones de la presión arterial.

INTRODUCTION

Blood pressure levels are the looking glass into the complex world of high blood pressure (HBP). HBP is the most prevalent and relevant manageable risk factor for premature death in adults world-wide. Overall, HBP represents a very relevant disease burden for the development of coronary heart disease, cerebrovascular disease, peripheral arterial disease, heart failure, kidney damage, cognitive impairment, and atrial fibrillation.[1,2]

HBP is diagnosed with blood pressure measurements, which is also helpful for classification, risk management, need for treatment initiation and adjustment and establishing management goals.[3,4] Methods available for the measurement of blood pressure include:

1. Casual measurement using mercury sphygmomanometer (currently prohibited in Mexico and many countries), aneroid devices or digital electronic devices.
2. In-office automated measurement (AOBPM) with equipment in which blood pressure is measured without the presence of an operator.
3. Ambulatory blood pressure measurement (ABPM).
4. Home measurement of blood pressure (HMBP).
5. Measurement of central blood pressure, which is carried out with varied and not entirely standardized methodologies.

CASUAL OFFICE MEASUREMENT OF BLOOD PRESSURE

Conventional measurement or casual measurement of blood pressure continues to be the most used and simplest indicator, although not the most desirable or optimal one, which

* Director del Instituto Mexicano de Salud Cardiovascular, Miembro GREHTA.
‡ Presidente de la Asociación Nacional de Cardiólogos de México, Miembro GREHTA.

Ciudad de México, México.

allows the diagnosis of HBP, treatment strategies and quality control.[5] Much of the information that exists on HBP has been obtained with this measurement method; however, more recently, the use of ambulatory blood pressure measurement has required in research studies, to improve reliability and reproducibility. Casual measurement has the advantages of being an easy technique, with various degrees of standardization, cheap and accessible; however, it is very susceptible to operator-dependent and equipment errors, introducing wide intra and inter-observer variability. Overall, casual BP measurement works like a snapshot taken to a continuous and highly variable phenomenon such as blood pressure. For this reason, it is increasingly considered that the clinical measurement of BP is a technique with little reproducibility and high variability; therefore, to perform an adequate diagnosis and control of elevated BP, other means should be considered.

The most important problem with casual BP measurement is that current guidelines establish precise cut-off points for pressure levels which are used in the diagnosis of HBP, for its classification, risk calculation, treatment initiation and goals achievement, even though the limited reproducibility of the office BP measurement is one of its main limitations. Sensitivity and specificity of casual BP measurement is < 75%, so 74 measurements would be needed to guarantee the validity of a difference of 5-7 mmHg. In contrast, the difference of 1mmHg would serve to declare someone with HBP or without it, e.g. with 139/89 would not be HBP and instead 140/90 would be, indicating precise cut-off points, with inexact measurements. That is why the most recent guidelines, although they accept that casual measurement is still the initial measurement technique, consider it valid and make precise recommendations for its measurement.

The ACC/AHA 2017, ESC/ESH 2018 guidelines and the «Scientific Statement of the AHA-2019» and the LASH 2020 Consensus agree that the confirmation of the diagnosis of HBP should be based on: 1) Repeated BP determinations at each visit at least 3 measurements separated by 1-2 min and at least in 2 visits and 2) BP measurement is obtained from the mean of the last 2 measurements, with the first being discarded, except for grade 3 HBP, in which it is enough their presence at a visit to ensure diagnosis.[3-5] The above is impractical and unrealistic. Casual blood pressure should always be measured carefully, following the rules established in all existing guidelines and consensus. The proper casual blood pressure measurement technique according to most recommendations includes:

1. Appropriate equipment validated and in good condition, which includes a cuff of appropriate size to the thickness and size of the patient's arm. The standard cuff is 12-13 cm wide and 35 cm long and can be useful for most patients, but for patients with arm circumference > 32 cm and for children special cuffs are required, which in most common electronic equipment are not available. Bracelets are not interchangeable in electronic equipment) and this is a major problem in the daily practice. Remember that a small bracelet, a frequent situation due to the high prevalence of obesity, can give a false high measurement between 10 and up to 40 mmHg.

2. The patient must be comfortably seated for 5 minutes before the recording, without having smoked, not having ingested caffeine and without having exercised in the previous thirty minutes. Without speaking, sitting with your back straight and feet flat on the floor. The patient should keep the arm with the cuff supported on a flat surface such as a table at heart level.

3. **At the first consultation:** measure BP in both arms. Use the arm with the highest BP value for future reference. Take 3 shots at an interval of 1-2 minutes between them, discard the first shot and average the last two. Some authors recommend two measurements and make a third when the differences between the previous two is > 10 mmHg.

4. Additional measurements may be necessary in patients with unstable BP values due to arrhythmias, such as patients with AF, in whom the manual auscultation method should be used since most automatic devices use the oscillometric method and are not validated

for measure BP in patients with AF. If an aneroid device is used, it should be calibrated frequently and Korotkoff sounds used in phase I (appearance of sounds) to determine systolic pressure and phase V (disappearance of sounds) to determine diastolic pressure.

5. Measure BP in both arms at first visit to detect possible differences. Reference the arm with the highest value.

6. At the first consultation, the BP of all patients is measured in the standing position, after 1 and 3 minutes of sitting, to exclude orthostatic hypotension.

7. Measurement of recumbent and standing BP is considered at subsequent consultations for the elderly, patients with diabetes, or those with other conditions in which orthostatic hypotension is common.

8. It is recommended to measure the heart rate by palpation of the pulse to rule out arrhythmia and to ensure the value of systolic blood pressure when the auscultatory method is used and in elderly patients to detect pseudo-HBP secondary to arterial hardening, which is determined by the Osler's maneuver if the radial pulse remains palpable, when the pressure cuff is inflated above the recorded systolic pressure.

We can summarize that the reliable measurement of casual blood pressure includes: its performance with adequate, validated, and calibrated equipment, with a technique carefully adhered to the recommendations and with multiple measurements in the same session and preferably in different visits.

MEASUREMENT OF BLOOD PRESSURE OUTSIDE THE OFFICE (ABPM AND MDDPA)

Importance and technique for obtaining the ABPM

Measurement of blood pressure outside the office, either through ABPM or a home measurement protocol, adds very valuable data on the characteristics of the hypertensive process. As BP is a parameter that varies greatly over time and can be influenced by the presence of an operator unfamiliar to the patient, the values obtained in the consultation, even under the best measurement conditions, may not be representative of the individual's BP throughout the day. Therefore, the measurement of pressure outside the office is used and recommended by guidelines and consensus more frequently.[6]

In the recommendations for the Latin American ABPM registry of 2021, the following are marked as advantages of ABPM:

1. Provides highly reproducible 24-hour, diurnal and nocturnal average values, capturing a circadian vision of the biological phenomenon.

2. Identifies white coat HBP and the phenomenon of masked HBP in treated and untreated individuals.

3. Detects nocturnal HBP and nocturnal descent patterns.

4. Evaluates the variability of blood pressure during a 24-hour period

5. Evaluates the efficacy of antihypertensive medication in 24 hours.

6. Detects the existence of periods of excessive drop in blood pressure.

7. Detects the existence of significant elevations in blood pressure upon awakening.

To this we must add that ABPM provides a greater number of readings than office blood pressure measurements and that it provides a profile of the behavior of blood pressure in the usual daily environment, which is a more accurate predictor of cardiovascular morbidity and mortality than casual measurement.[6]

The methodology for ABPM is reasonably standardized in multiple guidelines, consensuses, and recommendations, both for HBP and specific for this technique. The 2018 guidelines from the European Societies of Arterial Hypertension and Cardiology provide a very comprehensive description of out-of-office blood pressure measurement, and many of the concepts expressed here come from those guidelines:

For ABPM measurement, a validated commercial system cuff is placed on the patient's non-dominant arm, appropriate to the thickness of the arm, consisting of a cuff that inflates intermittently and automatically, at predetermined times for 24 hours, connected to a portable pressure recorder to measure blood

pressure day and night, during the patient's normal activities, so the patient should be instructed not to change their habits due to the presence of the device. It is recommended that when the patient feels that the cuff is inflated, they suspend their activities and, if possible, place their arm at heart level. It is convenient for the patient to write down in a diary if any type of symptomatology appears, the time of meals and taking medications, as well as the time of going to bed and getting out of bed.

The device is adjusted to take measurements every 15 minutes during the patient's activity time and every 30 minutes during sleep, in another way used in some centers the equipment is programmed to measure the pressure every 20 minutes uniformly throughout the day.[3]

The requirements to accept a MAP as valid are:

1. Validated device
2. ≥ 70% of the expected measurements must be valid.
3. 20 valid measurements in the awake phase (09:00-21:00 hours).
4. 7 valid in the sleeping phase (01:00-06:00 hours).
5. Circadian variability of blood pressure.

The most accepted indications for obtaining the ABPM are:

1. Suspicion of white coat phenomenon in untreated patients and unnecessary dose readjustments due to white coat in treated patients.
2. Suspected masked HBP in untreated patients and masked lack of control in treated patients.
3. Resistant HBP in treated subjects.
4. Obstructive sleep apnea.
5. Study of blood pressure variability.
6. Treatment evaluation.
7. Evaluation of HBP in the elderly.
8. Evaluation of HBP in children and adolescents.
9. Evaluation of HBP in pregnancy.
10. Evaluation of HBP in high-risk patients.
11. Identification of ambulatory hypotension.
12. Identification of blood pressure patterns in Parkinson's disease.

Home measurement of blood pressure or self-measurement of blood pressure

The widespread availability and relatively low price for the general population of semi-automatic digitized electronic devices for BP measurement offers an important alternative to self-monitoring of blood pressure (SBP); however, it is not recommended for home measurements at the time and in the form that the patient or their relatives decide, especially for immediate decision-making on the state of health and the modification of the treatment by the patient himself.[1,3,4]

Proper use of SBP requires an established protocol, which may represent a cheaper, albeit incomplete, alternative to ABPM, which we could call home blood pressure measurement (BPM). For this technique, as it has been described by the 2019 ESH/ESC guidelines, a minimum user training in the technique is required to the patient himself or a family member by the doctor, nurse, or health educators. This allows obtaining reliable measurements and the use of previously validated monitors must be ensured, so before purchasing the device, check if it is on a validated list. For example, the British Hypertension Society: (http//www.bhsoc.org/blood_pressure_list.stm) or the Italian Society: (www.pressionearteriosa.net) or the DABL (dableducational.org).

Although the devices that can be used for BPM are the same as for clinical measurement, in practice only oscillometric-type automatic electronic sphygmomanometers where cuff inflation is performed by a compressor that measure BP in the arm are recommended. Wrist braces are discouraged because they can lead to significant errors resulting from incorrect arm position and wrist flexion or hyperextension status, although the use of wrist gauges could be justified in obese patients with arm circumference extremely large. For diagnostic evaluation, BP should be measured daily for at least 3-4 days and preferably 7 consecutive days in the morning and in the afternoon. BP should be measured in a quiet room. The patient should sit down, with his back and arm supported, after 5 minutes of rest, and take two measurements each time 1-2 minutes apart.[7]

The results must be written down immediately after each measurement in a notebook specially designed for this purpose. The final value is the average of all readings except those from the first day of monitoring. The definition of normal values for home BP has been carried out based on cross-sectional population and cohort studies. It is accepted that the BP obtained by SBP is about 5 mmHg lower than that obtained in the consultation, for which the Scientific Societies arbitrarily establish the limit of normality at values lower than 135/85 mmHg, and the optimal value is recognized as lower than 130/80mmHg.

Interpretation of office and out-of-office BP measurements

The accepted cut-off points for the diagnosis of HBP are:

1. Casual measurement: >140/90 ESC/ESH, LASH, NOM. >130/80 ACC/AHA (Obtained by AOBPM).
2. MAP: average of 24 hours. > 130/80, daytime average >135/85, nighttime average >120/70.
3. BPM: > 135/85.

With combined office and SBP blood pressure measurement, four different patterns of blood pressure status in any given person can be found:

1. Normal BP (Patients with normal blood pressure in the office and in the ABPM or BPM)
2. White coat HBP – patients with HBP in the office but normal by ABPM or BPM.
3. Masked HBP – patients with normal BP in the office, but with HBP outside the office.
4. Sustained HBP – patients with HBP in the office and in any of the medications outside the office *(Figure 1)*.

White coat high blood pressure

White coat HBP is a phenomenon that occurs in patients who are not receiving antihypertensive medications, who have persistently high office BP (≥ 140/90 mmHg) and who are found to

have daytime pressure on ABPM or BPM a pressure < 135/85 mmHg. The prevalence of white coat HBP is between 15 and 25%, with the highest frequencies found in the elderly, females, and smokers. Out-of-office pressure monitoring to rule out white coat HBP is recommended in patients with office HBP without evidence of target organ damage, especially those with systolic pressures between 140 and 160 mmHg and diastolic between 90 and 100 mmHg. The prognosis of white coat HBP has traditionally and mistakenly been considered as benign; however, a high proportion of patients with this phenomenon progress to sustained HBP after one year and it is riskier for cardiovascular outcomes than pressure 121-139/81-89 mmHg, which indicates grade I HBP by ACC/AHA and high-normal by other guidelines.[3,4,8]

Masked high blood pressure

Individuals who have normal BP in consultations, but hypertensive in ambulatory blood pressure monitoring (ABPM) or in the protocolized home measurement, are considered to have masked HBP. Numerous terms have been used in the literature to refer to this type of HBP: masked, isolated ambulatory HBP, reverse white coat effect, or white coat normal BP, although the former is the most widely accepted. The prevalence of masked HBP varies according to the diagnostic criteria used and the characteristics of the population studied, but it is generally accepted that it ranges between 10-17%. Several factors have been described which can raise BP outside the office, such as young age, male
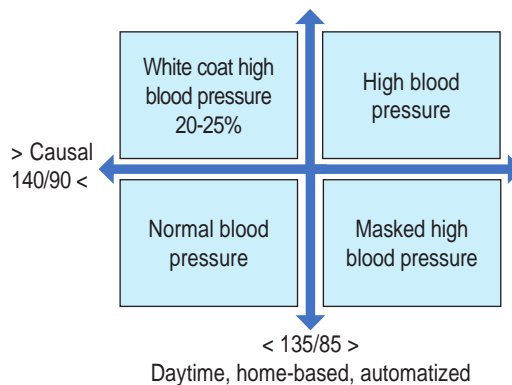
Figure 1: Circumstantial hypertension.

gender, smoking, alcohol consumption, physical activity, exercise-induced HBP, anxiety, work stress, obesity, and family history of HBP and it is especially prevalent in patients with diabetes or with kidney damage.

Masked HBP is frequently associated with other risk factors, such as asymptomatic organ damage and an increased risk of diabetes and sustained HBP and is more frequent in individuals with normal-high office BP figures. Individuals with masked HBP have greater organic involvement and worse cardiovascular prognosis than true normotensives. Some meta-analyses of prospective studies indicate that the incidence of cardiovascular outcomes is approximately two times higher than in true normotension and similar to the incidence in sustained HBP, although the fact that it is not detected in many cases, and therefore not treated, can contribute to these results.

Given that it is not feasible to study the population to detect masked HBP, efforts should be directed at detecting masked HBP in individuals with the highest index of suspicion and who will probably be the ones who can benefit most from treatment. Masked HBP should be suspected in normotensive individuals or with high-normal BP in the consultation, with other cardiovascular risk factors, signs of organic involvement inappropriate for BP values, and a family history of HBP in children or adolescents. It should also be suspected in hypertensive patients apparently well controlled by BP in consultation, in whom the expected regression of left ventricular hypertrophy or microalbuminuria progression or is not observed, and in those who present new cardiovascular events, such as stroke or heart failure decompensation congestive unexplained by other causes. In particular, the presence of masked HBP should be investigated in patients with diabetes mellitus with organ damage and borderline office blood pressures. In these patients, we should use 24-hours ABPM as the preferred method or BPM, which represents a good second option, especially for monitoring during treatment.[6,7]

CONCLUSIONS

Casual measurement of blood pressure is still the first recommended step to detect HBP in the population. The pressure measurement technique must be following very complete guidelines and according to the position document of the Alliance for a Healthy Heart. We recommend that blood pressure should be measured not necessarily by the doctor, but by trained health personnel equipped with adequate equipment, for which it would be very convenient to establish a blood pressure measurement module in each of the country's health centers. Here, the patient would receive an adequate measurement of his pressure figures before arriving at the consultation with the doctor. BPM is recommended, following an appropriate protocol, as a very useful alternative to ensure the correct diagnosis of HBP and rule out or confirm the presence of White Coat HBP and Resistant HBP. ABPM is an essential technique for data acquisition in research studies and its availability should be promoted in the first level of health care, to improve the control of HBP.

REFERENCES

1. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertens Dallas Tex 1979. 2018; 71: 1269-1324. Available in: https://doi.org/10.1161/HYP.0000000000000066

2. Alcocer L, Coca A, Ferrario CM. Revisión de las guías internacionales de hipertensión arterial. 978-84-17221-72-0 n.d. [Accesado Marzo 29, 2022] Disponible en: https://www.todostuslibros.com/libros/revision-de-las-guias-internacionales-de-hipertension-arterial_978-84-17221-72-0

3. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH). Eur Heart J. 2018; 39: 3021-3104. Available in: https://doi.org/10.1093/eurheartj/ehy339

4. Muntner P, Shimbo D, Carey RM, Charleston JB, Gaillard T, Misra S et al. Measurement of blood pressure in humans: a scientific statement from the American Heart Association. Hypertension. 2019; 73: e35-66. Available in: https://doi.org/10.1161/HYP.0000000000000087.

5. Alcocer L, Álvarez-López H, Borrayo-Sánchez G, Cardona-Muñoz EG, Chávez-Mendoza A, Díaz ED

et al. Hypertension as a persistent public health problem. A position paper from Alliance for a Healthy Heart, Mexico. Ann Clin Hypertens. 2019; 3: 009-30. Available in: https://doi.org/10.29328/journal.ach.1001015

6. Sánchez RA, Boggia J, Peñaherrera E, Barroso WS, Barbosa E, Villar R et al. Ambulatory blood pressure monitoring over 24 h: A Latin American Society of Hypertension position paper-accessibility, clinical use and cost effectiveness of ABPM in Latin America in year 2020. J Clin Hypertens Greenwich Conn. 2020; 22: 527-543. Available in: https://doi.org/10.1111/jch.13816.

7. Fabia MJ, Abdilla N, Oltra R, Fernandez C, Redon J. Antihypertensive activity of angiotensin II AT1 receptor antagonists: a systematic review of studies with 24 h ambulatory blood pressure monitoring. J Hypertens. 2007; 25: 1327-1336. Available in: https://doi.org/10.1097/HJH.0b013e3280825625

8. MRC trial of treatment of mild hypertension: principal results. Medical Research Council Working Party. Br Med J Clin Res Ed. 1985; 291: 97-104. Available in: https://doi.org/10.1136/bmj.291.6488.97

Correspondence:
Luis Alcocer Díaz-Barreiro, MD
E-mail: alcocerdb@hotmail.com