JAMA Diagnostic Test Interpretation

Ambulatory Blood Pressure Monitoring

Tamar S. Polonsky, MD, MSCI; George L. Bakris, MD, MA

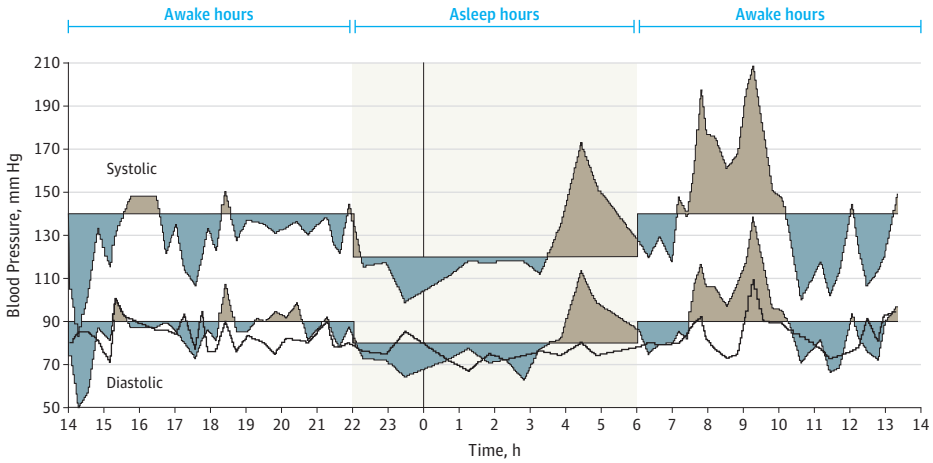

Figure. Patient's levels using a 24-h ambulatory BP monitor (gray indicates <140/90 mm Hg [daytime] and <120/80 mm Hg [during sleep]; brown indicates BP above the thresholds).

A 65-year-old woman presented to her primary care physician with concerns about large fluctuations in her blood pressure (BP). The patient's home BP measurements were often lower than 120/80 mm Hg but sometimes reached 200/100 mm Hg. She had a non–ST-segment elevation myocardial infarction 1 year ago and was treated with a drug-eluting stent in her right coronary artery. Her antihypertensive medications included carvedilol (12.5 mg, twice daily), lisinopril (40 mg daily), and chlorthalidone (12.5 mg daily). Additionally, the patient had generalized anxiety and panic disorders (treated with paroxetine, 30 mg), and she smoked for 90 pack-years but quit 2 months ago. The patient's office BP measurement was 127/74 mm Hg. Her physical examination was unremarkable.

Editorial page 1757

Supplemental content

Twenty-four-hour ambulatory BP monitoring was performed to evaluate patterns of elevated BP and potential etiologies. The patient kept a log of her diet, sleep pattern, and symptoms. Mean BP levels were 133/86 mm Hg overall (normal, <130/80 mm Hg); daytime, 135/88 mm Hg (normal, <135/85 mm Hg); and sleeping, 124/78 mm Hg (normal, <120/70 mm Hg).[1] During the first sudden increase in BP (04:00-06:00; **Figure**), she awoke from sleep with a panic attack. The second sudden increase (07:00-10:00) occurred after eating a high-sodium breakfast.

HOW DO YOU INTERPRET THESE RESULTS?

A. The patient has normal BP since the office BP was normal.

B. The patient has masked uncontrolled hypertension.

C. The patient has white coat hypertension.

D. The patient's BP dips appropriately during sleep.

Answer

B. The patient has masked uncontrolled hypertension.

Test Characteristics

Twenty-four-hour ambulatory BP monitoring measures BP over 24 hours, every 15 to 30 minutes during the day, and every 30 to 60 minutes during sleep (eTable in the Supplement). Observational studies consistently demonstrated that ambulatory BP monitoring is more predictive of clinical outcomes than office BP measurement.[1-4] Testing is indicated when clinicians suspect that office BP does not reflect ambulatory BP levels. White coat hypertension may be suspected in patients with office BP levels of 140/90 mm Hg to 169/99 mm Hg, who are nonsmokers, and who report anxiety at clinic visits; however, if patients with these characteristics are smokers, it is less likely that a clinician would suspect white coat hypertension because sustained hypertension is more common. Patients with normal office BP but hypertension-related end-organ damage, such as left ventricular hypertrophy, may have elevated ambulatory BP levels. A normal office BP without antihypertensive medication in a patient with elevated ambulatory BP is defined as having masked hypertension. Patients who meet criteria for masked hypertension and who are taking antihypertensive medication are classified as having masked uncontrolled hypertension.

The Centers for Medicare & Medicaid Services covers ambulatory BP monitoring to evaluate white coat hypertension. The prevalence of white coat hypertension is 10% to 35% among patients

evaluated for hypertension.[2,4,5] Medicare reimbursement is $50 to $70.[6] Some private insurers cover ambulatory BP monitors to evaluate additional phenotypes (see eTable in the Supplement), such as masked hypertension.[1,2] Over a 10-year period, more than 40% of adults with white coat or masked hypertension may develop sustained hypertension.[7]

Application of Test Result to This Patient

The patient's hypertension was associated with episodes of anxiety and high-sodium diet. Common causes of ambulatory hypertension include sleep disorders, medication nonadherence, tobacco use, and psychosocial stressors.[8] Adults with masked hypertension or masked uncontrolled hypertension are more than twice as likely to develop cardiovascular disease as normotensive adults.[4,9] Treatment should be based on potential etiologies (for this patient, anxiety and a high-sodium diet) and does not always require antihypertensive drugs.

Normally, nocturnal BP decreases between 10% and 19%. Decreases of 10% or less are considered as inadequate (known as nondipping). Elevated morning BP levels, as read on home BP monitors, can suggest inadequate dipping. In a registry of 17 312 adults with hypertension, nondipping was associated with a 27% higher risk of cardiovascular events.[10] Proposed explanations include increased sympathetic tone, arterial stiffness, or salt sensitivity. Strategies to treat nondipping include administering medication at night and treating sleep disorders. However, no randomized trials have evaluated whether restoring dipping with therapeutic interventions improves outcomes.

Ambulatory BP monitoring could be repeated to confirm BP control in high-risk patients. Home BP monitoring, if performed correctly, provides similar information as daytime ambulatory BP monitors.[2] Patients with white coat hypertension may benefit from repeat testing every 1 to 2 years to screen for sustained hypertension.[1]

Alternative Diagnostic Testing Approaches

Home BP monitors are a reasonable alternative for patients without access to ambulatory BP monitoring. Results of home BP monitors are independently associated with cardiovascular risk, after adjusting for office BP.[2,3] Advantages of ambulatory BP monitoring are that it includes nocturnal measurements, facilitates measurement outside of the home, does not rely on patient technique, and may be better tolerated by patients who experience anxiety with BP measurement. In contrast, home BP monitoring allows for BP measurement over more than 1 day and can also help improve BP control.[2]

Patient Outcome

The patient was encouraged to follow a low-sodium diet. She began a regimen of amlodipine (5 mg) in the evening to restore nocturnal dipping. Because some of her hypertensive episodes were associated with anxiety or mental stress, paroxetine was increased to 40 mg, and she was referred for counseling. Her daytime BP control improved, based on home BP monitoring. Her anxiety remained difficult to manage. The large increases in BP level during panic attacks continued, although her systolic BP rarely reached 160 mm Hg. A repeat ambulatory BP monitoring would have been reasonable, but was not performed.

Clinical Bottom Line

- Ambulatory BP monitoring is most often used to evaluate white coat hypertension.
- Progression from white coat hypertension to sustained hypertension is common.
- Additional hypertension phenotypes detected with ambulatory BP monitors include masked hypertension and nocturnal nondipping.
- Causes of masked hypertension or nondipping should be evaluated and treated accordingly (eg, high-sodium diet, sleep disorders, and psychosocial stress).

ARTICLE INFORMATION

Author Affiliations: Department of Medicine, University of Chicago Medicine, Chicago, Illinois.

Corresponding Author: Tamar S. Polonsky, MD, MSCI, 5841 S Maryland Ave, MC6080, Chicago, IL 60637 (tpolonsky@medicine.bsd.uchicago.edu).

Section Editor: Mary McGrae McDermott, MD, Senior Editor.

Conflict of Interest Disclosures: Dr Bakris reports receipt of grants from Janssen (steering committee, CREDENCE), Bayer (principal investigator, FIDELIO), AbbVie (steering committee, SONAR), Vascular Dynamics (steering committee, CALM-2); and personal fees from Merck (consultant) outside the submitted work. No other disclosures were reported.

Additional Contributions: We thank the patient for granting permission to publish this information.

REFERENCES

1. Parati G, Stergiou G, O'Brien E, et al. European Society of Hypertension practice guidelines for ambulatory blood pressure monitoring. *J Hypertens*. 2014;32(7):1359-1366.

2. Whelton PK, Carey RM, Aronow WS, 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. *Hypertension*. 2018;71(6):e13-e115.

3. Piper MA, Evans CV, Burda BU, et al. Diagnostic and predictive accuracy of blood pressure screening methods with consideration of rescreening intervals. *Ann Intern Med*. 2015;162(3):192-204.

4. Banegas JR, Ruilope LM, de la Sierra A, et al. Relationship between clinic and ambulatory blood-pressure measurements and mortality. *N Engl J Med*. 2018;378(16):1509-1520.

5. Stergiou GS, Asayama K, Thijs L, et al. Prognosis of white-coat and masked hypertension. *Hypertension*. 2014;63(4):675-682.

6. Centers for Medicare & Medicaid Services. Physician fee schedule. http://www.cms.gov/apps/physician-fee-schedule. Accessed May 10, 2018.

7. Mancia G, Bombelli M, Facchetti R, et al. Long-term risk of sustained hypertension in white-coat or masked hypertension. *Hypertension*. 2009;54(2):226-232.

8. Pickering TG, Davidson K, Gerin W, Schwartz JE. Masked hypertension. *Hypertension*. 2002;40(6):795-796.

9. de la Sierra A, Banegas JR, Vinyoles E, et al. Prevalence of masked hypertension in untreated and treated patients with office blood pressure below 130/80 mm Hg. *Circulation*. 2018;137(24):2651-2653.

10. Salles GF, Reboldi G, Fagard RH, et al. Prognostic effect of the nocturnal blood pressure fall in hypertensive patients. *Hypertension*. 2016;67(4):693-700.