

# The Importance of Accurate Blood Pressure Measurement

Joel Handler, MD

## Clinical Scenario

A woman, age 72 years, has blood pressures of 150/70 mm Hg and 150/80 mm Hg, obtained by a medical assistant (MA), on consecutive office visits and does not have a history of hypertension. The blood pressure cuff is properly sized, the MA is inquiring about the patient's last mammogram while obtaining the blood pressure, and the patient is helping to hold her arm up within the MA's grasp. The mean of a dozen blood pressure readings that the patient has obtained at home is 128/64 mm Hg. Does this patient have white-coat hypertension?

## Discussion

The most important commonly performed office test is blood pressure measurement, yet it is considerably undervalued. In the Kaiser Permanente Southern California (KPSC) Region, more than 2,300,000 blood pressure measurements were obtained by office staff in March 2009 (Ralph S Vogel, PhD, personal communication, 2009 April).<sup>4</sup> MAs often work in a rushed atmosphere, and physicians want their patients to be roomed promptly. However, populationwide, small inaccuracies in blood pressure measurement can have considerable consequences. Underestimating true blood pressure by 5 mm Hg would mislabel more than 20 million Americans with prehypertension when true hypertension is present. It has been predicted that the consequences of

an untreated 5 mm Hg of excessive systolic blood pressure would be a 25% increase over current levels of fatal strokes and fatal myocardial infarctions for these individuals.<sup>1</sup> Conversely, overestimating true blood pressure by 5 mm Hg would lead to inappropriate treatment with antihypertension medications in almost 30 million Americans, with attendant exposure to adverse drug effects, the psychological effects of misdiagnosis, and unnecessary cost.<sup>2</sup>

The trap is that in acknowledging the consequences of small measurement inaccuracies, errors of 5 to 10 mm Hg commonly occur as a result of improper blood pressure technique. Table 1 lists blood pressure aberrancies as a result of common errors. For example, active listening by the patient, when the MA is talking during blood pressure measurement, can increase systolic blood pressure by 10 mm Hg.<sup>3</sup> Obtaining a measurement from an unsupported arm can increase the systolic pressure by 10 mm Hg. Lack of back support and crossed legs increase blood pressure. If a patient needs to urinate, a blood pressure measurement taken before bladder emptying can increase the systolic pressure by >10 mm Hg. Measurements taken over clothing or with tight clothing pushed up on the arm, causing a tourniquet effect, also produce significant artifacts.<sup>4</sup> However, although many textbooks state that the bell of the stethoscope is more reliable than the diaphragm, studies show that is not the case.<sup>5,6</sup>

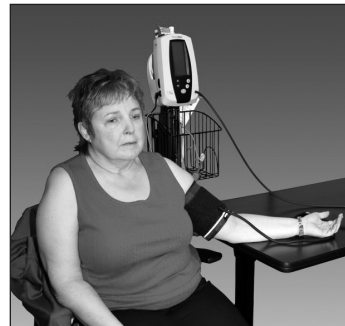


Figure 1. Proper performance of a sitting blood pressure measurement. Note a proper-size cuff over a bare upper arm, which is positioned at heart level and supported on a table; the patient's back is supported and her feet are on the floor.

The commonplace use of the diaphragm side of the stethoscope is satisfactory. Figure 1 illustrates the proper technique for obtaining a sitting blood pressure.

## Terminal Digit Preference

Terminal digit preference, a common source of error during manual blood pressure examinations, is the rounding off of numbers to the nearest zero. Usually the result is an inappropriate increase in the diagnosis of hypertension because systolic pressures in the upper 130s are rounded up to 140 mm Hg. In a KPSC blood pressure survey, 22% of recorded blood pressure numbers ended in zero; the expected occurrence would be 10%. Those results are better, however, than those from one literature survey, which reported that 78% of recorded

**... overestimating true blood pressure by 5 mm Hg would lead to inappropriate treatment with antihypertension medications in almost 30 million Americans, with attendant exposure to adverse drug effects, the psychological effects of misdiagnosis, and unnecessary cost.<sup>2</sup>**

Joel Handler, MD, is an Expert Panel Member of the Eighth Joint National Committee on High Blood Pressure; Hypertension Clinical Lead, Care Management Institute; and Hypertension Lead for Southern California Kaiser Permanente, Anaheim, CA. E-mail: joel.handler@kp.org.

Factor	Magnitude of systolic/diastolic blood pressure discrepancy (mm Hg)
Talking or active listening	10/10
Distended bladder	15/10
Cuff over clothing	5–50/
Cuff too small	10/2–8
Smoking within 30 minutes of measurement	6–20/
Paralyzed arm	2–5/
Back unsupported	6–10/
Arm unsupported, sitting	1–7/5–11
Arm unsupported, standing	6–8/

blood pressure numbers terminated in zero.<sup>7,8</sup> Although studies have been reported showing that an automated oscillometric device that provides five serial blood pressure measurements reduces the white-coat effect compared with manual determinations,<sup>9,10</sup> another study has shown that blood pressure is underestimated by this device, leading to significant misclassification of hypertension.<sup>11</sup> The use of an automatic blood pressure monitor does have the advantage of obviating terminal digit preference,<sup>12</sup> but the plethora of potential patient preparation errors still remain.

#### Forearm Blood Pressure

What about taking a forearm blood pressure on an obese patient? Nurses often find that it is faster and easier to take a forearm blood pressure than to search for a larger cuff. Studies have shown that forearm blood pressures generally run 3.6/2.1 mm Hg higher than upper arm blood pressures.<sup>13,14</sup> The experience in KPSC has been that once clinicians and MAs are taught how to obtain forearm blood pressures, inappropriate usage of forearm pressures becomes commonplace. Therefore, we no longer teach this technique. Instead, the regional mandate is to have both standard and large blood pressure cuffs in every primary care examination room. Using a standard blood pressure arm cuff on

an obese patient falsely raises systolic blood pressure by approximately 10 mm Hg. “Miscuffing” should be strongly discouraged.

#### Proper Technique

For which patients is a standing blood pressure measurement most appropriate, and what is the proper technique for obtaining one? Particularly in patients who are  $\geq 70$  years old and taking antihypertension medications, obtaining standing blood pressure measurements should be routine practice. Although the sitting blood pressure measurement represents the standard in hypertension treatment trials, standing systolic pressure decreases of  $\geq 20$  mm Hg, consistent with a diagnosis of orthostatic hypotension,



Figure 2. Proper measurement of a standing blood pressure requires complete arm support with cuff at heart level. Hold the arm if an adjustable table is unavailable.

commonly occur and raise safety and quality-of-life issues in geriatric patients already at risk for dizziness and falling. Therefore, the National High Blood Pressure Working Group report on Hypertension in the Elderly concluded “... if the standing blood pressure is consistently much lower than the sitting blood pressure, the standing blood pressure should be used to titrate drug doses during treatment.”<sup>15</sup> An international neurology consensus statement endorsed waiting “within three minutes” in the standing position<sup>16</sup> and others have clarified this recommendation as being three minutes,<sup>17</sup> but the protocol used in the landmark Hypertension in the Very Elderly Trial (HYVET) waited two minutes.<sup>18</sup> Having patients stand for two to three minutes before their upright blood pressure measurement is taken is reasonable for hypertension management. When blood pressure is properly measured in the standing position, the arm should be supported (Figure 2). When measurement is taken on a dangling arm, the systolic pressure may artifactually be 6 to 10 mm Hg higher than in an arm that is properly supported.<sup>19,20</sup>

#### Doctor or Nurse or Medical Assistant

Who should be measuring the blood pressure after all, physician or nurse? In all of the hypertension treatment trials, blood pressure has been measured by trained nonphysicians, usually nurses. White-coat effect is common and persistent. In a classic study of nurse and physician blood pressures undertaken in patients with continuous intra-arterial blood pressure monitoring, two concurrent measurement phenomena were observed: observer effect and alerting reaction (Figure 3). After a few minutes, a repeat blood pressure measurement obtained by both a physician and a nurse produced

“... if the standing blood pressure is consistently much lower than the sitting blood pressure, the standing blood pressure should be used to titrate drug doses during treatment.”<sup>15</sup>

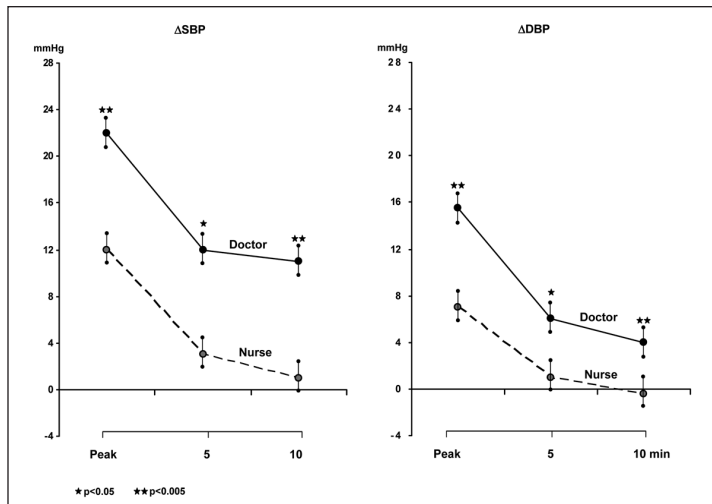


Figure 3. Demonstration of relative blood pressure alerting reactions and observer effects, comparing physician and nurse.

ΔSBP = change in systolic blood pressure, ΔDBP = change in diastolic blood pressure. Reprinted with permission from Mancia G, Parati G, Pomidossi G, Grassi G, Casadei R, Zanchetti A. Alerting reaction and rise in blood pressure during measurement by physician and nurse. *Hypertension* 1987 Feb;9(2):209–15.

results about 10/5 mm Hg lower than the first determination, owing to mitigation of the alerting reaction. Nonetheless, there was a difference of 10/5 mm Hg between the physician and the nurse with both the first and second determinations, demonstrating the persistence of the observer, or white-coat, effect.<sup>21</sup> Patients are more afraid of physicians than of nurses. If an initial blood pressure reading obtained by an MA is elevated and a physician then obtains a follow-up reading, that second reading may be lower because the alerting reaction has subsided, or it may be higher because of doctor-related white-coat effect. Physicians taking blood pressure measurements should be knowledgeable regarding proper technique and the causes of artifacts.

Multiple competent blood pressure measurements by MAs can obviate the white-coat effect. Two studies have shown that several measurements obtained by nurses can approximate mean blood pressure measurements obtained by 24-hour ambulatory blood pressure recordings.<sup>22,23</sup> The discrepancy between

office blood pressure measurements and 24-hour ambulatory measurements is at least in part because of poor office competence in obtaining accurate readings. When there is concern regarding the possibility of the white-coat effect, having MAs obtain weekly blood pressure measurements for two weeks should be considered. Whenever the first blood pressure reading is elevated, a second reading should be obtained after a one-minute interval.

### Patients

Patients are increasingly helpful as quality-assurance monitors. Educational materials are available to teach proper home blood pressure measurement technique, and other general patient-education materials demonstrating blood pressure measurement competency have been distributed. On a few occasions, we have received accurate criticism of blood pressure measurement technique performed by our staff from patients in KPSC. Also, peer-validator competency review of blood pressure measurement by

MAs is expanding in our system: MAs receiving peer-validator training offer critiques and instruction to their colleagues in a program that has generated positive feedback from participants. Additionally, a new blood pressure measurement training video is being developed, with “train-the-trainer”<sup>8</sup> Webinars planned for later in 2009.

### Conclusions

The patient whose case was presented at the beginning of this article does not have hypertension despite the elevated office readings, and she does not need home blood pressure measurements for a diagnosis of white-coat hypertension to be made. White-coat hypertension indicates a dissociation between competently determined office blood pressure elevations and normal blood pressure readings obtained at home. Therefore, findings for this patient do not qualify for a diagnosis of white-coat hypertension, because the office blood pressure readings are inaccurate. Terminal digit preference

**If an initial blood pressure reading obtained by an MA is elevated and a physician then obtains a follow-up reading, that second reading may be lower because the alerting reaction has subsided, or it may be higher because of doctor-related white-coat effect.**



Photograph courtesy of Mid-Atlantic States Region, Kaiser Permanente.

Figure 4. What is wrong with the blood pressure measurement technique in this picture? Can you list all ten errors? (Key to answers on page 54.)

is a marker of inaccurate office technique: all four office measurements for the patient ended in zero. Active listening by the patient, from whom medical information was requested during blood pressure measurement, and partial patient support of her outstretched arm could easily have accounted for a systolic artifact of >10 mm Hg. This patient was exposed to the possibility of receiving an inaccurate diagnosis of hypertension and taking inappropriate antihypertension medications. Her case illustrates potential patient care problems ensuing from poor office blood pressure measuring technique.

Take a minute to examine Figure 4 and list all ten errors in obtaining the sitting blood pressure shown. (Key to answers listed below.) ♦

<sup>a</sup> Practice Leader, Data Consulting and Report Production, Southern California Permanente Medical Group Clinical Analysis

#### Disclosure Statement

The author(s) have no conflicts of interest to disclose.

#### Acknowledgment

Katharine O'Moore-Klopf, ELS, of KOK Edit provided editorial assistance.

#### References

- Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet* 2002 Dec 14;360(9349):1903-13. Erratum in: *Lancet* 2003 Mar 22;361(9362):1060.
- Jones DW, Appel LJ, Sheps SG, Roccella EJ, Lenfant C. Measuring blood pressure accurately: new and persistent challenges. *JAMA* 2003 Feb 26;289(8):1027-30
- Le Pailleur C, Helft G, Landais P, et al. The effects of talking, reading, and silence on the "white coat" phenomenon in hypertensive patients. *Am J Hypertens* 1998 Feb;11(2):203-7.
- Reeves RA. The rational clinical examination. Does this patient have hypertension? How to measure blood pressure. *JAMA* 1995 Apr 19;273(15):1211-8.
- Cushman WC, Cooper KM, Horne RA, Meydrech EF. Effect of back support and stethoscope head on seated blood pressure determinations. *Am J Hypertens* 1990 Mar;3(3):240-1.
- Kantola I, Vesalainen R, Kangassalo K, Kariluoto A. Bell or diaphragm in the measurement of blood pressure. *J Hypertens* 2005 Mar;23(3):499-503.
- Wen SW, Kramer MS, Hoey J, Hanley JA, Usher RH. Terminal digit preference, random error, and bias in routine clinical measurement of blood pressure. *J Clin Epidemiol* 1993 Oct;46(10):1187-93.
- Bennett S. Blood pressure measurement error: its effect on cross-sectional and trend analyses. *J Clin Epidemiol* 1994 Mar;47(3):293-301.
- Myers MG, Valdivieso M, Kiss A. Use of automated office blood pressure measurement to reduce the white coat response. *J Hypertens* 2009 Feb;27(2):280-6.
- Beckett L, Godwin M. The BpTRU automatic blood pressure monitor compared to 24 hour ambulatory blood pressure monitoring in the assessment of blood pressure in patients with hypertension. *BMC Cardiovasc Disord* 2005 Jun 28;5(1):18.
- Culleton BF, McKay DW, Campbell NR. Performance of the automated Bp TRU measurement device in the assessment of white-coat hypertension and white-coat effect. *Blood Press Monit* 2006 Feb;11(1):37-42.
- Roubanthisuk W, Wongsurin U, Saravich S, Buranakijjaroen P. Blood pressure determination by traditionally trained personnel is less reliable and tends to underestimate the severity of moderate to severe hypertension. *Blood Press Monit* 2007 Apr;12(2):61-8.
- Singer AJ, Kahn SR, Thode HC Jr, Hollander JE. Comparison of forearm and upper arm blood pressures. *Prehosp Emerg Care* 1999 Apr-Jun;3(2):123-6.
- Pierin AM, Alavarce DC, Gusmão JL, Halpern A, Mion D Jr. Blood pressure measurement in obese patients: comparison between upper arm and forearm measurements. *Blood Press Monit* 2004 Jun;9(3):101-5.
- National High Blood Pressure Education Program Working Group report on hypertension in the elderly. National High Blood Pressure Education Program Working Group Hypertension 1994 Mar;23(3):275-85.
- Kaufmann H. Consensus statement on the definition of orthostatic hypotension, pure autonomic failure and multiple system atrophy. *Clin Auton Res* 1996 Apr;6(2):125-6.
- Wieling W, Schatz JJ. The consensus statement on the definition of orthostatic hypotension: a revisit after 13 years. *J Hypertens* 2009 May;27(5):935-8.
- Beckett NS, Peters R, Fletcher AE, et al; HYVET Study Group. Treatment of hypertension in patients 80 years of age or older. *N Engl J Med* 2008 May 1;358(18):1887-98.
- Familoni OB, Oluunuga TO. Comparison of the effects of arm position and support on blood pressure in hypertensive and normotensive subjects. *Cardiovasc J S Afr* 2005 Mar-Apr;16(2):85-8.
- Netea RT, Lenders JW, Smits P, Thien T. Influence of body and arm position on blood pressure readings: an overview. *J Hypertens* 2003 Feb;21(2):237-41.
- Mancia G, Parati G, Pomidossi G, Grassi G, Casadei R, Zanchetti A. Alerting reaction and rise in blood pressure during measurement by physician and nurse. *Hypertension* 1987 Feb;9(2):209-15.
- Pearce KA, Grimm RH Jr, Rao S, et al. Population-derived comparisons of ambulatory and office blood pressures. Implications for the determination of usual blood pressure and the concept of white coat hypertension. *Arch Intern Med* 1992 Apr;152(4):750-6.
- Jula A, Puukka P, Karanko H. Multiple clinic and home blood pressure measurements versus ambulatory blood pressure monitoring. *Hypertension* 1999 Aug;34(2):261-6.

**Figure 4. What is wrong with the blood pressure measurement technique in this picture? Key for errors:** 1) Patient's arm is unsupported; 2) Patient's back is unsupported; 3) Patient is talking; 4) Patient is engaged in active listening; 5) Wrong size cuff in use ("miscuffing"); 6) Blood pressure cuff is positioned too low on the upper arm; appears to be over the elbow; the artery marker on the cuff is probably malpositioned as well; 7) Cuff is over clothing; 8) Observer is not at eye level with the monitor; where is the monitor? 9) Patient's legs are crossed; 10) End of stethoscope is in clinician's coat pocket.