Does This Patient Have Hypertension?

How to Measure Blood Pressure

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CLINICAL SCENARIO

Is This Patient's Blood Pressure Really Elevated?

A 46-year-old man who has recently moved to your neighborhood presents with a painful ankle sprain. Before he leaves, you decide to check his blood pressure (BP) and obtain an initial reading of 164/102 mm Hg. He denies having high BP previously.

WHY IS ACCURATE BP MEASUREMENT IMPORTANT?

Elevated arterial BP, or hypertension, is important because it is common, it is clinically silent, it leads to cardiovascular disease (CVD), and it decreases life expectancy. Because surveys find that approximately 20%[1-3] of North American adults have an elevated BP (systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg) or are taking antihypertensive medication, physicians are advised to check all patients periodically for BP elevation.[3-7] On the other hand, overestimation of BP can erroneously label people as hypertensive and potentially result in unnecessary dietary restrictions, exposure to potential side effects from drug treatment, medication expense, and adverse socioeconomic effects.[8,9] Fortunately, measuring BP is an easy and safe diagnostic procedure that, when followed by appropriate antihypertensive drug treatment, can lead to reduced CVD and mortality.[10,11]

STANDARDS FOR MEASURING BP

The "gold" standard for instantaneous BP measurement is the intra-arterial or direct BP (determined by a rigid-walled catheter). The standard for clinical practice is the so-called casual cuff or indirect BP.

Guidelines for Diagnosing Hypertension

Cardiovascular disease risk rises monotonically with BP, revealing no cut point below which risk is minimal and above which CVD will definitely occur. Terms used to indicate the degree of BP elevation now emphasize the importance of what was previously termed mild hypertension and the long-recognized greater predictive value of elevated systolic BP[12] (Table 1). Risk for future CVD is predicted by even a single careful BP reading.[13-15] However, BP is rather variable and often decreases with observation so that, in accord with statistical expectations, risk relates more closely to mean BP over several visits[13] (although brief, severe BP elevation can also be catastrophic, eg, with cocaine overdose). Therefore, we could define the "treatable BP level" as that mean clinical BP above which treatment has been shown in randomized controlled trials to do more good than harm. The largest of these trials used drug treatment vs placebo after finding a consistent or average entry BP from two to three visits of greater than or equal to 160 mm Hg systolic (tested only in the elderly) with or without diastolic BP elevation,[16] or greater than or equal to 90 mm Hg diastolic (tested in the young and in the elderly).[11] In the future, individualized assessments of absolute risk incorporating other relevant information, such as age, sex, concomitant risk factors, and coexisting target organ damage, along with the patient's tolerance for risk and history of drug side effects may replace arbitrary cut points in determining when BP elevation becomes treatable.[7] At present, a diagnosis of hypertension reflects a consensus regarding the office BP level above which CVD risk worsens importantly, about 140/90 mm Hg.

A detailed conceptual analysis of hypertension is beyond the scope of this article, but has been addressed thoughtfully by Jennings and Netsky.[17]

How to Measure Clinical BP

Meticulous technique in indirect auscultatory BP measurement is mandatory for research, for diagnosis, and for optimal clinical care of hypertensive patients. Published procedural guidelines show general uniformity.[3-5,18-20] The accuracy and reliability of BP measurement will be increased by following the widely accepted procedures recommended by the American Heart Association (Table 2, Figure 1). Blood pressure is customarily measured after obtaining the medical history as part of the "vital sign" determination at the beginning of the physical examination. At each visit, two or more readings should be obtained and averaged from the same

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Table 1.—Classification of Blood Pressure for Adults Aged 18 Years and Older*

Category	Systolic, mm Hg	Diastolic, mm Hg
Normal	<130	<85
High normal	130-139	85-89
Hypertension†		
Stage 1 (mild)	140-159	90-99
Stage 2 (moderate)	160-179	100-109
Stage 3 (severe)	180-209	110-119
Stage 4 (very severe)	≥210	≥120

*Adapted from the fifth report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure.[3]

†Based on the average of two or more readings taken at each of two or more visits after an initial screening.

arm with the subject supine or seated. As a practical approach to variability, taking additional readings until a stable level is reached has been suggested when the first two differ by more than 5 mm Hg diastolic.[20] Blood pressure in both arms should be measured at the first visit, and the arm with the higher pressure should be used thereafter.[18]

Careful technique guarantees maximum accuracy. We have compiled information from a number of sources regarding factors that increase, decrease, or have no effect on BP[21-74] (Table 3). However, if all serious errors that can underestimate BP are avoided, finding the BP in any setting, position, or time to be within the normal range makes a more careful measurement at that visit unlikely to be high. Assuming BP is checked on a routine basis in all adults, the efficient practitioner can reasonably reserve the "proper" method for the 10% to 20% of patients who have known or newly detected elevated BP (as in our clinical scenario), cardiovascular target organ damage, or other risk factors or who are receiving antihypertensive therapy.

Variation in BP Measurement

Sources of clinical variability include the patient, equipment, examiner, and procedure. For BP, a major proportion of random fluctuation over time arises from the examinee. Intra-arterial monitoring clearly reveals that systolic and diastolic BP differ with every heartbeat and with the respiratory cycle.[45] Blood pressure also varies minute-to-minute, with an SD of about 4 mm Hg systolic and 2 to 3 mm Hg diastolic,[59,75] as well as over hours[76,77]; short-term variability in systolic BP is increased with impaired baroreflexes.[77,78] Day-to-day variation is even greater. With two or more cuff readings at each visit, the SD between visits is approximately 5 to 12 mm Hg systolic and 6 to 8 mm Hg diastolic.[13,59,60,79,80] This variability explains why two BP measurements in a patient often differ, but it also suggests that a repeat visit's measurements could be as

Table 2.—Technique for Measuring Blood Pressure*

The intent and purpose of the measurement should be explained to the subject in a reassuring manner and every effort made to put the subject at ease. [Include a 5-minute rest before the first measurement.]

The sequential steps for measuring the blood pressure in the upper extremity, as for routine screening and monitoring purposes, should include the following:

1. Have paper and pen at hand for immediate recording of the pressure.
2. Seat the subject in a quiet, calm environment [with feet flat on the floor, back against the chair] with his or her bared arm resting on a standard table or other support so the midpoint of the upper arm is at the level of the heart.
3. Estimate by inspection or measure with a tape the circumference of the bare upper arm at the midpoint between the acromium and olecranon process and select an appropriately sized cuff. The bladder inside the cuff should encircle 80% of the arm in adults and 100% of the arm in children less than 13 years old. If in doubt, use a larger cuff. If the available cuff is too small, this should be noted.
4. Palpate the brachial artery and place the cuff so that the midline of the bladder is over the arterial pulsation, then wrap and secure the cuff snugly around the subject's bare upper arm. Avoid rolling up the sleeve in such a manner that it forms a tight tourniquet around the upper arm. Loose application of the cuff results in overestimation of the pressure. The lower edge of the cuff should be 1 in (2 cm) above the antecubital fossa where the head of the stethoscope is to be placed.
5. Place the manometer so the center of the mercury column or aneroid dial is at eye level [except for tilted-column floor models] and easily visible to the observer and the tubing from the cuff is unobstructed.
6. Inflate the cuff rapidly to 70 mm Hg, and increase by 10 mm Hg increments while palpating the radial pulse. Note the level of pressure at which the pulse disappears and subsequently reappears during deflation. This procedure, the palpatory method, provides a necessary preliminary approximation of the systolic blood pressure to ensure an adequate level of inflation when the actual, auscultatory measurement is made. The palpatory method is particularly useful to avoid underinflation of the cuff in patients with an auscultatory gap and overinflation in those with very low blood pressure.
7. Place the earpieces of the stethoscope into the ear canals, angled forward to fit snugly. Switch the stethoscope head to the low-frequency position (bell). The setting can be confirmed by listening as the stethoscope head [ie, the bell orifice] is tapped gently.
8. Place the head of the stethoscope over the brachial artery pulsation, just above and medial to the antecubital fossa but below the edge of the cuff, and hold it firmly [but not too tightly[21]] in place, making sure that the head makes contact with the skin around its entire circumference. Wedging the head of the stethoscope under the edge of the cuff may free up one hand but results in considerable extraneous noise [and is nearly impossible with the bell in any event].
9. Inflate the bladder rapidly and steadily to a pressure 20 to 30 mm Hg above the level previously determined by palpation, then partially unscrew (open) the valve and deflate the bladder at 2 mm [Hg]/sec while listening for the appearance of the Korotkoff sounds.
10. As the pressure in the bladder falls, note the level of the pressure on the manometer at the first appearance of repetitive sounds (Phase I) and at the muffling of these sounds (Phase IV) and when they disappear (Phase V). During the period the Korotkoff sounds are audible, the rate of deflation should be no more than 2 mm per pulse beat, thereby compensating for both rapid and slow heart rates.
11. After the Korotkoff sound is heard, the cuff should be deflated slowly for at least another 10 mm Hg, to ensure that no further sounds are audible, and then rapidly and completely deflated, and the subject should be allowed to rest for at least 30 seconds.
12. The systolic (Phase I) and diastolic (Phase V) pressures should be immediately recorded, rounded off (upwards) to the nearest 2 mm Hg. In children, and when sounds are heard nearly to a level of 0 mm Hg, the Phase IV pressure should also be recorded [example: 108/64/56 mm Hg]. All values should be recorded together with the name of the subject, the date and time of the measurement, the arm on which the measurement was made, the subject's position, and the cuff size (when a nonstandard size is used).
13. The measurement should be repeated after at least 30 seconds, and the two readings averaged. In clinical situations, additional measurements can be made in the same or opposite arm, in the same or an alternative position.

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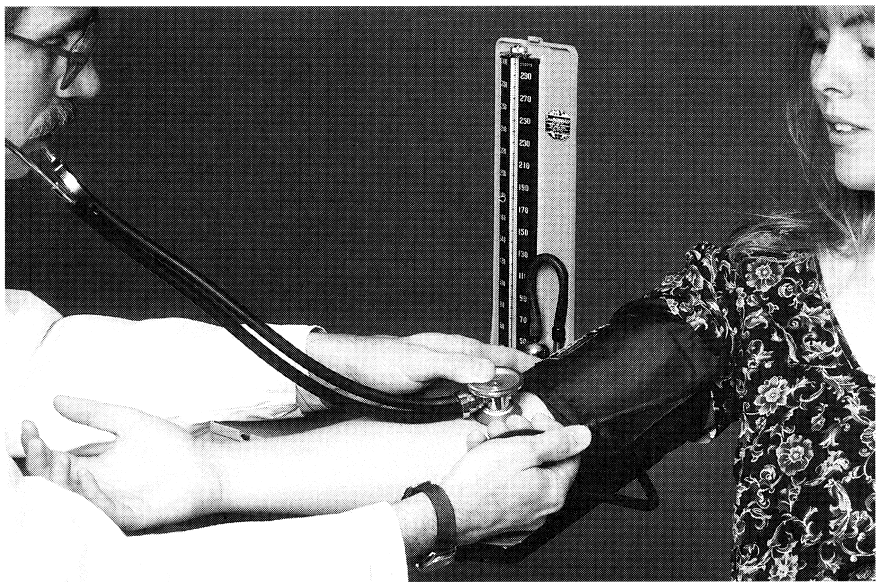

Figure 1.—Clinical measurement of indirect blood pressure.

much as 15/12 mm Hg higher or lower than today's result about 5% of the time. The greater magnitude of the between- vs within-visit variability is the reason why more visits are recommended to achieve greater diagnostic precision rather than more replications at a visit. In reality, the return BP reading in our clinical scenario will likely be lower, possibly much lower, because of our patient's present distress, unfamiliarity with the physician and the physician's office procedures, and "regression to the mean" (discussed herein).

Arrhythmias, particularly atrial fibrillation, cause beat-to-beat cardiac output to vary substantially and increase interobserver variation in measured BP.[81] With atrial fibrillation, probably the best one can do is to deflate the cuff slowly while attempting to ascertain when most of the contractions are resulting in audible Korotkoff sounds (the approximate systolic BP) and when the sounds have all but ceased yet still occur infrequently (the approximate diastolic BP), or one can average several readings.[18,20] Because Korotkoff sounds generated by occasional premature beats (and the subsequent beat) are unrepresentative of the day's mean BP level, they should be ignored.[22]

Examiners can introduce random errors. Under ideal conditions, simultaneous BP readings by independent observers typically correlate above r=0.95 with mean absolute differences of less than 2 mm Hg systolic and less than 1 mm Hg diastolic.[82] However, even in research settings, careful BP readings obtained just a few minutes apart show distressingly high variation (eg, SD of 7 mm Hg systolic and 5 mm Hg diastolic[13,54,61]). In routine medical practice, physicians and nurses often measure BP far less carefully: differences of 10/8 mm Hg are common.[83,84] White et al[85] performed intra-arterial BP recording in 48 hypertensive patients and found the humbling result that two auscultatory automatic monitors showed less overall discrepancy and fewer widely discrepant readings than did experienced clinicians using the standard method.

Environmental problems (eg, noise from construction work next door) or deficient equipment (eg, an inadequately damped, "bouncy" mercury column, remedied by tightening the knurled nut at the column's top[22]) may also be expected to decrease precision.

Accuracy of BP Measurement

Accuracy, or validity, refers to agreement with the truth and requires not only precision but also freedom from systematic error (ie, bias). In clinical BP measurement, we look through a series of dark glasses, further considered herein: (1) the indirect BP may not reflect the concurrent intra-arterial BP; (2) the cuff technique may be incorrectly performed; and (3) a perfectly executed indirect (or even direct) BP reading at a particular moment may not represent the patient's average clinic BP nor the average BP throughout the day's activities, as addressed in the section on ambulatory BP monitoring. Finally, to interpret even a perfect BP reading requires consideration of the whole patient because factors other than BP strongly influence the risk for CVD events.

Table 3.—Factors Affecting the Immediate Accuracy of Office BP*

Factor	Magnitude, SBP/DBP, mm Hg	Reference
Increases Recorded BP		
Examinee		
Soft Korotkoff sounds	DBP	Assumed
Missed auscultatory gap	DBP (rare, huge)	22
Pseudohypertension	2 to 98/3 to 49	23-25
"White coat" reaction		
To physician	11 to 28/3 to 15	26-30
To nonphysician	1 to 12/2 to 7	27, 31, 32
Paretic arm (due to stroke)	2/5	33
Pain, anxiety	May be large	22
Acute smoking	6/5	34
Acute caffeine	11/5	35
Acute ethanol ingestion	8/8	36
Distended bladder	15/10	37
Talking; signing	7/8	38; 39
Setting, equipment		
Environmental noise	DBP	Assumed
Leaky bulb valve	≥2 DBP	40
Blocked manometer vents	2 to 10	41
Cold hands or stethoscope	Not stated	22
Examiner		
Expectation bias	Probably <10	In theory
Impaired hearing	DBP	22
Examination		
Cuff too narrow	−8 to +10/2 to 8	42-44
Cuff not centered	4/3	45
Cuff over clothing	5 to 50	46
Elbow too low	6	47
Cuff too loose	Not stated	48
Too short rest period	Varied estimates	22
Back unsupported	6 to 10	49, 50
Arm unsupported	1 to 7/5 to 11	51
Too slow deflation	−1 to +2/5 to 6	52, 53
Too fast deflation	DBP only	52, 53
Parallax error	2 to 4	By author
Using phase IV (adult)	6 DBP	45
Too rapid remeasure	1/1	52, 54
Cold season (vs warm)	6/3 to 10	55-57

(continued)

Indirect BP vs Direct BP.—Indirect auscultatory BP correlates well with the simultaneous intra-arterial value (r=0.94 to 0.98).[86] However, the Korotkoff phase I sounds do not appear until 15 to 4 mm Hg below the direct systolic BP, whereas at phase V, the sounds disappear 3 to 6 mm Hg above the true diastolic BP in adults.[45,85,86]

If these technical differences applied equally to all patients, they would be merely academic; clinical importance arises when an individual patient possesses an unusual discrepancy. Such patients are often elderly (where false elevation is termed "pseudohypertension"[23,24,87-89]) or obese,[46] but otherwise unexplained extreme false elevations in cuff BP may also occur.[90] Pseudohypertension might seem at first glance to be a variant of normal BP. However, most patients actually have chronic hypertension,[91] on which is superimposed a further false BP elevation. Although it has been claimed that pseudohypertension can be suspected in an older person if "Osler's sign" (while feeling the radial pulse, occlude the brachial artery by cuff inflation or by direct pressure using the other thumb; if the radial artery remains

Table 3.—Factors Affecting the Immediate Accuracy of Office BP* (cont)

Factor	Magnitude, SBP/DBP, mm Hg	Reference
Decreases BP		
Examinee		
Soft Korotkoff sounds	SBP	Assumed
Recent meal	−1 to 1/1 to 4	58
Missed auscultatory gap	10 to 50 SBP	45
High stroke volume	Phase V can = 0	45
Habituation	0 to 7/2 to 12	59-61
Shock (additional pseudohypotension)	33 SBP	62
Setting, equipment		
Noisy environs	SBP	Assumed
Faulty aneroid device	Can be >10	63
Low mercury level	Varies	22
Leaky bulb	≥2 SBP	40
Examiner		
Reading to next lowest 5 or 10 mm Hg, or expectation bias	Probably ≤10	64
Impaired hearing	SBP only	22
Examination		
Noisy environs	SBP	Assumed
Left vs right arm	1/1	65
Resting for too long (25 min)	10/0	66
Elbow too high	5/5	47
Too rapid deflation	SBP only	40
Excess bell pressure	≥9 DBP	21
Parallax error (aneroid)	2 to 4	By author
No Effect on BP		
Examinee		
Menstrual phase	. . .	67, 68
Chronic caffeine ingestion	. . .	69
Phenylephrine nasal spray	. . .	70
Cuff self-inflation	. . .	71
Examinee and examiner		
Discordance in sex or race	. . .	72, 73
Examination		
Thin shirtsleeve under cuff	. . .	74
Bell vs diaphragm	. . .	49
Cuff inflation per se	. . .	29
Hour of day (during work hours)	. . .	54
Room temperature	. . .	54

*BP indicates blood pressure, and SBP and DBP indicate systolic and diastolic BP, respectively.

palpable as a firm "tube," the sign is positive) is present,[24] the test's usefulness remains debatable.[25,91,92] For example, in 65 geriatric patients unanimously classified "Osler-positive" or "Osler-negative" by three observers, six other physicians demonstrated moderate intraobserver consistency (κ=0.49) and only modest interobserver agreement (κ=0.37).[93] Retaining "Osler-equivocal" patients in the study would almost certainly have further reduced agreement. Confirming pseudohypertension requires an intra-arterial BP measurement; fortunately, the condition is uncommon, affecting less than 2% of one otherwise healthy elderly group.[25]

Technical Inaccuracies of Indirect BP.—Examiner biases include end-digit preference (ie, the tendency to over-record certain numbers, particularly 0 and 5[64,75,94,95]), recording lower values at critical diagnostic cut points[64] presumably to avoid institution of long-term drug treatment, and probably other analogous unconscious processes (eg, "observing" a hoped-for BP reduction consequent to instituting therapy). Physicians may also differ when labeling patients as hypertensive. A group of British general practitioners diagnosed hypertension after only one BP measurement in 58% of patients despite previously agreeing to use three readings as part of the group's uniform diagnostic criteria.[96] Contrary to their local expert guidelines, about 37% of German out-of-hospital[97] physicians and British hospital clinicians[98] record phase IV (muffling) rather than the more accurate Korotkoff phase V. Perhaps the most common technical error is failure to use a sufficiently large cuff; indeed, in one survey, only 25% of primary care physicians even owned a large cuff.[63]

Interestingly, even when an automatic BP recorder is used, systematic differences between operators in the BP values obtained may remain,[99] suggesting differing examinee reactions to different examiners, as was seen in one careful study in children.[100]

Directional equipment errors can occur. Aneroid instruments often go out of adjustment, usually downward.[52] One survey found that 34% of practitioners used only aneroid units, of which 30% were off by 10 mm Hg or more.[63] A mercury unit can yield biased readings if the meniscus does not rest at 0 or if the mercury's descent is impeded by clogged internal air vents.[41] The stethoscope type seems relatively unimportant.[49] Although the recommended bell amplifies the Korotkoff sounds' low frequencies in comparison with the diaphragm,[101] the risk of exerting excessive pressure and obtaining a falsely low diastolic BP when using the bell[21] may outweigh the benefit of amplification, particularly in thin patients (try a small bell with a rubber rim).

Examination errors are legion (Table 3); most overestimate the true BP. Note also that confirming an apparent difference between arms is not simple because it requires taking the averages of several alternating measurements from both sides or simultaneous measurements by two observers who then switch sides and remeasure.[102]

Office BP vs Usual BP.—Shortly after entering the office, patients' systolic BP declines by several millimeters of mercury, whereas diastolic BP remains relatively constant.[53,59,60,66,100,103] Blood pressure remains fairly steady throughout the customary working daytime hours,[54] declines in the evening (ie, at home),[104,105] and finally drops another 10% to 20% during sleep.[106,107] In some patients, BP in a physician's office is notably and consistently higher than daytime ambulatory BP. This phenomenon, termed "office" or "white coat" hypertension,[108] can even occur during self-measurement of cuff BP in the presence of a physician.[26] Approximately 10% to 40% of untreated and nominally borderline hypertensive patients show an appreciable "white coat" effect,[27,109] and many treated patients will also show differences of greater than 20/10 mm Hg.[109,110] The phenomenon may depend in part on patient factors such as sex, age, and BP level.[111] For example, one group of elderly patients showed an increase in BP of 17/7 mm Hg on entering the physician's office; women showed a greater systolic BP rise than men.[28,112] Who wears the white coat seems to matter, since nurses (who, along with technicians, have generally performed the BP measure-

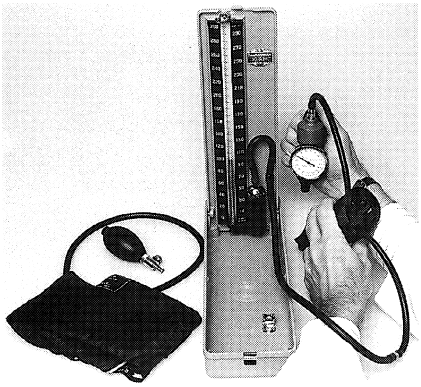

Figure 2.—How to calibrate a portable aneroid manometer against a mercury unit: (1) Disconnect both bulbs from the cuffs. Reconnect the aneroid bulb/dial assembly to the mercury unit's cuff (already connected to the column). Applying a few drops of water to the metal connector will facilitate its insertion into the rubber tubing. Close the aneroid assembly valve. Roll the cuff up loosely so that it is held by its Velcro strips. If necessary to prevent unrolling, first wrap the cuff around a sturdy large bottle or other surrogate "arm," or simply use a steady handgrip. (2) Gradually and steadily inflate the cuff until the mercury column rises to about 90 mm Hg. Holding the dial near the column, compare the two readings. (3) Obtain repeat readings at several other pressures, eg, 160 mm Hg, 220 mm Hg, 40 mm Hg. Modification for wall-mounted aneroid devices: Remove and set aside the aneroid cuff by disconnecting its tubing from its metal connector. Leave the dial tubing connector still coupled. Slightly inflate the mercury unit's cuff, and pinch the bulb tubing closed (fingers or clamp). Remove the bulb and replace it with the two coupled connectors running to the aneroid dial. Roll up the cuff. Squeeze the rolled-up cuff by hand to proceed as outlined in steps (2) and (3).

ments used for entry to the large clinical trials) seem to evoke a smaller BP increase than physicians.[29,113]

THE ISSUE OF PREDICTION

BP Now vs BP Later

Systematic (and therefore at least partially predictable) changes in BP between visits occur for several reasons. As examinees (volunteers or patients) become more familiar with the examiner, environment, and procedure (including BP self-measurement[26]), BP decreases by 0 to 7 mm Hg systolic and 2 to 12 mm Hg diastolic.[59-61] This habituation may be more marked in patients with anxiety trait.[114] An additional and probably more important factor,[115] regression to the mean, represents the tendency for any unusually high (or low) reading to fall closer to the population mean when repeated. These phenomena are distinguishable from a true "placebo" effect since they can occur in the absence of placebo treatment.[13,59,116] Some BP changes likely represent currently unappreciated systematic influences; for example, a systematic reduction in BP of about 6 mm Hg occurs during warm vs cold seasons.[55-57]

Major outcome trials of antihypertensive pharmacotherapy have used two to three BP readings taken at each of two or more visits not only to increase precision (by "averaging out" minute-to-minute and between-day random fluctuations), but also to partially control for regression to the mean and habituation. In practice, following the same multivisit protocol helps ensure that published trial results will be applicable to individual patients. (A further refinement, used naturally by many experienced clinicians, is to conduct further follow-up visits when the BP is hovering near a diagnostic cut point. Patients whose true values are far from this threshold [above or below] logically need fewer visits for confident classification.[117]) In practice, the interval between visits should take into account both the BP level and the patient's clinical status. The Joint National Committee[3] recommends remeasurement within 1 month for BP initially in the range of 160 to 179 mm Hg systolic or 100 to 109 mm Hg diastolic (ie, stage 2), within 2 months for stage 1, within 1 week for stage 3, and immediate evaluation for stage 4.

Relative Risk of Casual BP Elevation for Persistent Hypertension

Given high random variation, how well does the finding of a single elevated BP predict later definite hypertension? Casual BP, particularly systolic BP at one visit, is predictive of later BP elevation in young men,[118] medical students,[119] adults,[13] and children.[120] (Tracking correlations vary widely; for example, r=0.2 to 0.7, depending on the population, technique, and follow-up interval.) In a large prospective study,[121] one diastolic BP reading greater than or equal to 90 mm Hg predicted a later definite diagnosis of hypertension in 69% of men and 49% of women; any BP elevation warrants careful follow-up. Looked at the other way, however, about one third to one half of subjects with initially elevated BP will ultimately prove not to have hypertension. In practice, regression to the mean guarantees that many individuals with initially elevated BP are really normotensive.[75] For example, among subjects with four diastolic BP measurements at two entry visits averaging between 95 to 104 mm Hg in a mild hypertension trial in Australia,[122] 28% proved to have an average diastolic BP less than 90 mm Hg during the next 4 years on placebo. In a careful screening program, similar diastolic BP reductions were seen in the 105 to 114 mm Hg stratum from the first to second screen, and approximately 10% of subjects with diastolic BP greater than or equal to 115 mm Hg were normotensive (<90 mm Hg) at the next visit.[116] Therefore, using the mean of several visits' BP readings improves the ability to predict not only future hypertension[120] but also CVD sequelae.[13] Because he may be normotensive, the patient in our case scenario should not be told that he is hypertensive at this initial visit,[4] but he should be carefully followed up.

Is a High BP Value Ever Normal?

In normotensive subjects, aerobic exercise, which is generally accepted to be good for health, causes systolic BP to increase moderately while diastolic BP changes little.[123,124] Since increased BP forms part of the "fight or flight" response, pain (eg, a lacerated finger) and other stresses (eg, pulmonary edema) predictably raise BP, sometimes to extreme values. These reactive elevations of BP do not indicate the presence of "hypertension" if the BP returns to normal levels at rest.

How Do I Improve My Technique?

Checking one's equipment periodically is mandatory to preserve accuracy.[19] Aneroid devices should be recalibrated at least every 6 months. The recommended approach involves inserting a Y-connector somewhere in the pressurized path between bulb and mercury column and attaching the aneroid device. An alternative method not requiring a Y-connector is given in Figure 2. Although one can measure arm circumference in each patient to select an appropriately sized cuff, one can more efficiently mark the limit of arm circumference directly on each cuff by drawing a line in indelible ink at a distance from the free bladder end equal to twice the measured bladder width.

Tape recordings can help standardize observers' identification of Korotkoff sounds.[84,125] Alternatively, locate a two-headed stethoscope (and a second set of ears attached to a willing expert brain) for hands-on training. Initial formal training in the technique of BP measurement is necessary, but in addition, periodic review of technique and retraining as needed are recommended.[4] Retraining can increase accuracy,[83] but may be needed every 1 to 2 months for optimal effect,[126] a frequency probably practical only in research settings. Atrial fibrillation requires a modified technique (discussed earlier). When faced with soft Korotkoff sounds, have the subject elevate the arm and then open and close the fist several times; inflate the cuff, lower the arm (with further inflation as needed), and listen again. In this situation, as permitted by some guidelines,[4] more rapid deflation after determination of the systolic BP until the vicinity of the diastolic BP will minimize attenuation of the Korotkoff sounds arising from ve-

nous congestion without altering the measured BP.[53] Applying the cuff with its tubing emerging at the top[19] will eliminate extraneous noises generated if tubing contacts the stethoscope.

For research purposes, random-zero sphygmomanometers will reduce but still not eliminate observer bias. Fully automatic devices, if otherwise technically accurate, should eliminate certain human foibles (eg, end-digit preference[94] and selective recording of "desirable" readings). Statistical monitoring[54] to detect end-digit preference or excessive variability followed by mandatory retraining should be helpful.

In practice, the grossest error, not checking BP at all, remains a common failing even among cardiovascular subspecialists.[127] Most measurement errors could be obviated if practitioners would only follow the published recommendations[19,128-132]; alas, many do not.[63,96-98]

Other Ways to Measure BP

Lacking the ability to hear properly, both systolic and diastolic BP (as noted by Janeway, among others) can be determined by palpation to within about 10 mm Hg.[133] Palpated systolic BP is about 7 mm Hg lower than the auscultatory value.[134]

Potential Improvements in the Diagnosis of Hypertension

Elevated BP during aerobic exercise testing in subjects normotensive at rest has some predictive value for subsequent definite hypertension (relative risk from 2.3 to approximately 7).[123,124,135] Because BP is so variable during daily activity, ambulatory BP monitoring[136-138] ought to provide a better estimate of whole-day target organ exposure. Ambulatory BP monitoring correlates better with coexisting target organ damage[138] and a retrospective follow-up study suggested improved prediction for subsequent CVD.[139] However, some patients cannot tolerate ambulatory BP monitoring and accurate measurements are not always possible (eg, with marked arrhythmia or obesity).[140] Although appropriate studies have begun,[141] no data yet exist to show that adding ambulatory BP monitoring results in clinical benefit, and issues such as cost-effectiveness remain.[136]

Self-measurement of BP[142] is also under active study. Concurrent accuracy,[82] the meaning of differences in measurements at home and at work,[143] and concerns about selective reporting remain. When patients bring in their own, usually lower home BP readings, be certain to explain that only antihypertensive treatment of resting BP readings is of proven value, that daytime BP is routinely higher than evening BP, and that cardiac involvement may relate more closely to worktime BP.[144] Although the appeal of self-monitoring includes potentially desirable psychological and compliance effects, any benefit remains questionable[142]; a 1-year trial of home BP monitoring found no difference in treatment, attained BP, or risk factor reduction.[145]

THE BOTTOM LINE

Hypertension remains one of the most prevalent and most important public health problems. Measurement of BP has won its place in the recommended periodic health examination because hypertension is common, clinically silent, dangerous, and treatable. Accurately measuring BP by the indirect method requires minimal equipment combined with a willingness to make the effort; all health care practitioners should read and follow published guidelines.[18] Attention to proper technique plus an appreciation of the inherent variability of BP should yield an accurate diagnosis in most patients. Occasional patients with suspected pseudohypertension or white coat syndrome may benefit from ancillary technology such as echocardiography or ambulatory BP monitoring to optimize diagnostic decision making. Conversely, in the far more common, otherwise low-risk patient, yearly BP readings will suffice to exclude the presence of severe or long-standing untreated hypertension. The patient in our clinical scenario would be served well by a return visit in a few weeks for repeat BP measurement,[3] whereas immediately labeling him as hypertensive would be incorrect and, by causing him unnecessary concern, could be an immediate disservice.

Following expert treatment guidelines constitutes the physician's final responsibility, tying a proper diagnosis and proven therapy together to benefit the patient.

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