Difference Between Clinic and Daytime Blood Pressure Is Not a Measure of the White Coat Effect

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Abstract—The purpose of the present study was to evaluate whether the difference between blood pressure measured in the clinic or physician’s office and the average daytime blood pressure accurately reflects the blood pressure response of the patient to the physician (“white coat effect” or “white coat hypertension”). We studied 28 hypertensive outpatients (mean age, 41.8±11.2 years; age range, 21 to 64 years) of 35 consecutive patients attending our hypertension clinic, in whom (1) continuous noninvasive finger blood pressure was recorded before and during the visit, (2) blood pressure was measured according to the Riva-Rocci-Korotkoff method (mercury sphygmomanometer) with the patient in the supine position, and (3) daytime ambulatory blood pressure was monitored with a SpaceLabs 90207 device. The peak blood pressure increase recorded directly during the visit was compared with the difference between clinic and daytime average ambulatory blood pressures. Compared with previsit values, peak increases in finger systolic and diastolic blood pressures during the visit to the clinic were 38.2±3.1 and 20.7±1.6 mm Hg, respectively (mean±SEM, P<.01 for both). Daytime average systolic and diastolic blood pressures were 135.5±2.5 and 89.2±1.9 mm Hg, with both lower than the corresponding clinic blood pressure values (146.6±3.6 and 94.9±2.2 mm Hg, P<.01). These differences, however, were <30% of the peak finger blood pressure increases during the physician’s visit, to which these increases showed no relation. Although the visit to the physician’s office was associated with tachycardia (9.0±1.6 bpm, P<.01), there was no difference between clinic and daytime average heart rates. These data indicate that the clinic—daytime average blood pressure difference does not reflect the alerting reaction and the pressure response elicited by the physician’s visit and thus is not a reliable measure of the white coat effect. (Hypertension. 1998;31:1185-1189.)

Key Words: blood pressure monitoring, ambulatory ■ stress ■ risk factors ■ hypertension, white coat ■ blood pressure

Ambulatory blood pressure monitoring has shown that in most subjects, daytime blood pressure is lower than clinic blood pressure.1–3 This difference is ascribed to the “white coat effect” (ie, the alerting reaction and pressor response of the patient to the measurement of blood pressure in the clinic environment).4–6 As a result, subjects with a clinic blood pressure of >140/90 mm Hg and a daytime blood pressure below this value are called “white coat hypertensives.”4,5

No demonstration has ever been given, however, that the clinic—daytime blood pressure difference is due to a white coat effect and therefore the term “white coat hypertension” is appropriate. In the present study, we addressed this issue by measuring in the same subjects the clinic—daytime blood pressure difference and the actual pressor response to blood pressure measurements by a physician in the clinic environment.

Methods

Subjects
Thirty-five hypertensive patients were considered for inclusion in the study. Seven of the patients were not included in the analysis because of poor-quality ambulatory (n=3) or finger (n=1) blood pressure recording or because of frequent cardiac arrhythmias (n=3), which prevented an accurate blood pressure monitoring from being obtained. Thus, the study population consisted of 28 outpatients (10 men and 18 women) with an age range of 21 to 64 years (mean±SD age, 41.8±11.2 years). All patients were seen for the first time in our outpatient center because of the recent detection of blood pressure elevation during a visit with their family physician. The patients were recruited if they had mild essential hypertension (ie, clinic diastolic blood pressure [average of three values] of 91 to 104 mm Hg). Patients were untreated or had their antihypertensive treatment withdrawn for 3 weeks. Additional inclusion criteria were no history or evidence of cerebrovascular, cardiac, or renal complications or damage; no serious concomitant cardiovascular or noncardiovascular disease; no major arrhythmias; body mass index of <27 kg/m²; and evidence of a good-quality finger blood pressure signal (see below) at a preliminary recording session held in the outpatient clinics. The patients consented to the procedure after information was provided that their blood pressure was going to be measured through different techniques to more fully characterize their hypertensive condition. The study protocol was approved by the ethics committee of the institutions involved.

Measurements
Blood pressure measurements made were those often used for hypertensive patients at our clinic. Clinic blood pressure was measured according to the Riva-Rocci-Korotkoff method (mercury sphygmomanometer) with the patient in the supine position, and (3) daytime ambulatory blood pressure was monitored with a SpaceLabs 90207 device. The peak blood pressure increase recorded directly during the visit was compared with the difference between clinic and daytime average ambulatory blood pressures. Compared with previsit values, peak increases in finger systolic and diastolic blood pressures during the visit to the clinic were 38.2±3.1 and 20.7±1.6 mm Hg, respectively (mean±SEM, P<.01 for both). Daytime average systolic and diastolic blood pressures were 135.5±2.5 and 89.2±1.9 mm Hg, with both lower than the corresponding clinic blood pressure values (146.6±3.6 and 94.9±2.2 mm Hg, P<.01). These differences, however, were <30% of the peak finger blood pressure increases during the physician’s visit, to which these increases showed no relation. Although the visit to the physician’s office was associated with tachycardia (9.0±1.6 bpm, P<.01), there was no difference between clinic and daytime average heart rates. These data indicate that the clinic—daytime average blood pressure difference does not reflect the alerting reaction and the pressure response elicited by the physician’s visit and thus is not a reliable measure of the white coat effect. (Hypertension. 1998;31:1185-1189.)
obtained from the nondoninant arm with a mercury sphygmomanometer; the first and fifth Korotkoff sounds were taken to identify systolic and diastolic values, respectively. Heart rate was measured according to the palpatory method (30 seconds) after the blood pressure measurement was made. Ambulatory blood pressure recording was obtained for 24 hours with a SpaceLabs 90207 device; the cuff was applied to the nondoninant arm. The ambulatory recording was started at 0:00 AM and to accurately follow rapid and marked changes of intra-arterial blood pressure induced with a variety of stimuli. The device was set to allow automatic blood pressure measurements every 15 minutes from 7 AM to 11 PM and every 20 minutes from 11 PM to 7 AM. All recordings were performed on working days (Monday through Friday). The subjects were instructed to attend to their usual activity during the recording period and to return to the outpatient clinic the following morning for device removal.

Blood pressure also was continuously monitored for 45 minutes with a finger device (Finapres 2300; Ohmeda), which was previously shown to provide values similar to those obtained intra-arterially from the radial artery and to accurately follow rapid and marked changes of intra-arterial blood pressure induced with a variety of stimuli. The device cuff was wrapped around the mid or ring finger of the nondoninant arm. The finger blood pressure recording was performed in the outpatient clinic with the patient in the supine position and the instrumented hand positioned at the heart level. The device was calibrated at the beginning of the recording by inducing stepwise changes in pressure from 0 to 200 mm Hg through the device pump, which was connected to a mercury column. The recording was started after demonstration that (1) the average of three finger blood pressure values agreed within ±5 mm Hg with the average of three values taken simultaneously from the same arm by the ausculotatory method via a Y tube connected to a mercury column. The recording started after demonstration that (1) the average of three finger blood pressure values agreed within ±5 mm Hg with the average of three values taken simultaneously from the contralateral arm with a mercury sphygmomanometer and (2) the between-arm blood pressure difference was ≤±5 mm Hg.

Protocol

The study began with a visit by a physician unknown to the patients to measure clinic blood pressure (and heart rate) with the patient in the supine position for 5 minutes. The visit started with a brief patient history and included three sphygmomanometric blood pressure and three heart rate measurements at minutes 3, 5, and 8 of a 15-minute period. It also included a physical examination focused on the cardiovascular system, which was performed in the final minutes of the visit. All patients then underwent the 24-hour ambulatory blood pressure monitoring and the 45-minute finger blood pressure recording, which were obtained within 1 week of the initial visit with a 1- to 2-day interval between each other. To obtain a direct measure of the white coat effect, a 20-minute period during the visit, the supine patients were visited by another physician they had not previously met. The physician was instructed to measure blood pressure with a mercury sphygmomanometer according to the procedure adopted routinely for hypertensive patients. The visit lasted 15 minutes, and measurements were made at minutes 3, 5, 8, 11, and 13 of the visit. The sphygmomanometric values determined by the physician on this visit were not used to calculate the “clinic” blood pressure value (which was based on the sphygmomanometric values of the first visit) but were used to determine whether the peak finger blood pressure rise during the visit might coincide with any of the time of physician’s visit.

Data Analysis

In each patient, the three clinic systolic blood pressure, diastolic blood pressure, and heart rate measurements obtained during the initial visit were averaged and referred to as the “clinic blood pressure and heart rate.” Systolic blood pressure, diastolic blood pressure, and heart rate values obtained with ambulatory monitoring during the daytime also were averaged. The daytime period was defined as the period between 7 and 11 AM during which the subject’s diary indicated the subject was awake. Finger blood pressure data were recorded (Racal Recorders) and analyzed. First, the analog blood pressure signal was sampled at 168 Hz, converted with a precision of 12 bits, and stored on a computer disk. Second, systolic and diastolic blood pressures were computed for each blood pressure wave, and heart rate was derived as the reciprocal of the interval between consecutive systolic peaks. Third, heat-to-beat values were averaged for each minute of the 45-minute recording. Fourth, average values were obtained for the 10-second period showing the maximal increase in both systolic and diastolic blood pressures during the visit and a 10-second period during the 5 minutes before the visit. The corresponding 10-second heart rate values also were calculated. The differences between clinic and average daytime values were taken as the traditional (and indirect) measure of the white coat effect. Direct assessment of the white coat effect was obtained by computing the differences between peak 10-second finger blood pressure during the visit and the 10-second values before the visit.

Data from individual subjects were pooled and expressed as mean±SEM for the group as a whole. The statistical significance of the differences in mean values was assessed with a Student’s t test for paired observations. Correlations between direct and indirect measures of the white coat effect were examined by computing Pearson’s correlation coefficient. A value of P<.05 was taken as the level of statistical significance.

Results

For the 28 subjects, average clinic systolic and diastolic blood pressures were 146.6±3.6 and 94.9±2.2 mm Hg, respectively. Corresponding daytime values were significantly lower (135.5±2.5 and 89.2±1.9, P<.01), and the averages of the individual clinic−daytime differences were 11.1±3.5 (systolic) and 5.7±2.4 (diastolic) mm Hg. Thus, according to the conventional indirect approach used with these subjects, there was a noticeable average white coat effect.

The 28 subjects showed a marked and persistent increase in finger blood pressure during the physician’s visits compared with the measurements during the previst and postvisit periods (Figs 1 and 2). In most subjects, however, the magnitude of the peak finger blood pressure increase (ie, directly measured white coat effect) was considerably greater than the white coat effect indirectly quantified as the difference between clinic blood pressure (average of three values) and daytime blood pressure.
On average, the peak finger blood pressure increase was 38.2 ± 3.1 mm Hg for systolic blood pressure and 20.7 ± 1.6 mm Hg for diastolic blood pressure, with values more than threefold the average clinic—daytime blood pressure differences (Fig 3, top). The peak increase in finger blood pressure directly recorded during the physician’s visit and the clinic—daytime blood pressure differences also were not significantly related to each other (Fig 3, bottom). This was also true for the corresponding heart rate values. Indeed, although when directly recorded, heart rate showed an average clear-cut increase during the physician’s visit, clinic heart rate was on average lower than daytime heart rate (Figs 1 through 3).

Fig 4 shows the timing of the peak blood pressure response measured directly during the physician’s visit. Peak changes occurred at a variable time during the visit, and only in a small number of subjects did they coincide with one of the five sphygmomanometric blood pressure measurements made during the visit. This was reflected by the lack of correlation between the peak increase in finger systolic blood pressure during the physician’s visit and the average or highest sphygmomanometric systolic blood pressure value obtained for the visit during which clinic blood pressure was determined ($r = 0.23$ and 0.20, respectively; $P = NS$). Similar results were obtained for diastolic blood pressure ($r = 0.25$ and 0.20, respectively; $P = NS$).

**Figure 2.** Blood pressure (BP) and heart rate (HR) effects of the physician’s visit. Data are shown as average ±SEM 1-minute values of a 15-minute period before the visit, the 15-minute visit (between vertical lines), and a 10-minute period after the visit for the entire group of 28 patients. Systolic (S) and diastolic (D) 1-minute averages are illustrated separately.

**Figure 3.** Comparison between the clinic—average daytime blood pressure (BP) difference (CBP—ABP) and the increase in BP and heart rate (HR) directly measured during the physician’s visit (white coat effect [WCE]) (n=28). Both individual and average ±SEM group data are shown separately for systolic BP (SBP), diastolic BP (DBP), and HR (top). Bottom, Lack of a significant within-subject correlation between CBP—ABP and WCE values. **+=**Statistical significance of the differences between the two sets of values ($P < .01$).

**Figure 4.** Timing of the maximal increase in both systolic and diastolic finger blood pressure during the physician’s visit. Vertical bars indicate number of subjects showing a maximal blood pressure increase during the 15-minute visit; arrows, timing of cuff blood pressure measurements by the physician.
Discussion

In our subjects, the increase in blood pressure triggered by the visit of an unfamiliar physician in charge of measuring blood pressure was greater than the difference between conventional clinic and daytime average blood pressures. Furthermore, the physician-dependent increase in blood pressure and the clinic—daytime blood pressure difference showed no relation to each other when clinic blood pressure was obtained with an average of three values and when the highest clinic value was considered. Finally, although the increase in blood pressure triggered by the physician was accompanied by a sizable tachycardia, clinic heart rate was on average lower than daytime heart rate. These findings provide evidence that the clinic—daytime blood pressure difference does not reliably reflect the alerting reaction and the pressure response elicited in the patient by blood pressure measurement by a physician. Taking this difference as a measure of the white coat effect is therefore erroneous. It consequently is also erroneous to call patients white coat hypertensives if they have a clinic blood pressure of \( >140/90 \) mm Hg and a daytime ambulatory blood pressure of \( <140/90 \) mm Hg or any other arbitrary blood pressure level. A more appropriate term for these subjects should be the descriptive term isolated clinic hypertensives.\(^\text{11}\)

Several aspects of the present study deserve discussion. First, it can be suggested that the difference between the higher blood pressure measured in the clinic environment and the lower pressure recorded during the daytime was smaller and unrelated to the white coat effect directly quantified through continuous finger blood pressure recording because previous visits had made the patients less reactive to sphygmomanometric measurements. However, (1) in our patients, direct assessment of the white coat effect always followed the visit in which clinic blood pressure was determined, (2) the diagnosis of hypertension had been made only recently and all patients were seen in our center for the first time, and (3) most importantly, the clinic—daytime blood pressure difference is persistent over time (G.P. and G.M., unpublished data from the Study on Ambulatory Monitoring of Pressure and Lisinopril Evaluation [SAMPLE]) and only slightly reduced with treatment.\(^\text{12}\) Thus, it can be excluded that habituation to sphygmomanometric measurements is responsible for a less pronounced clinic—daytime blood pressure difference compared with the directly measured white coat effect. Second, it also can be suggested that the response of finger blood pressure to the physician’s visit was greater because of the anxiety inherent to the novelty of the continuous blood pressure monitoring procedure. However, before the physician’s visit, finger blood pressure was by no means elevated. Furthermore, and more importantly, in a previous study, we have shown the white coat effect measured directly with continuous blood pressure monitoring to be unchanged for several visits.\(^\text{2}\) Thus, that the procedure involved in the direct assessment of the white coat effect caused an exaggerated finger blood pressure response can also be excluded. Third, it can be suggested that the clinic—daytime blood pressure difference originates from a white coat effect but fails to reflect the actual size of this phenomenon because as reflected by the lack of correlation between clinic blood pressure and the peak increase in finger blood pressure during the physician’s visit, clinic blood pressure measurements seldom correspond to the variable time at which blood pressure shows its maximal increase during the physician’s visit (see Fig 4). It should be emphasized, however, that the true white coat effect differed from the clinic—daytime blood pressure difference not only quantitatively but also qualitatively (ie, although the true white coat effect was accompanied by tachycardia, the clinic—daytime heart rate difference was if anything a negative difference). We thus believe that another possibility is most likely, namely that the clinic—daytime blood pressure difference originates not so much from a greater or lesser effect of emotion on clinic blood pressure but rather from factors that modulate daily life blood pressure level and lead to an increase or reduction in daytime blood pressure that may differ among subjects.\(^\text{13–15}\)

Another possibility, which is not exclusive of the above possibility, is that, of course, as an average of a large number of values, daytime blood pressure achieves an immediate regression to the mean.\(^\text{7,16,17}\) A third possibility is that a greater concordance between the true white coat effect and its surrogate measure could be obtained by considering only the ambulatory values around the time at which the visit was made. However, this procedure would be opened to the disadvantage that ambulatory blood pressure within a limited time window has a poor and varying reproducibility.\(^\text{18}\) Furthermore, in our study, as in most surrogate assessments of the white coat effect, clinic blood pressure and ambulatory blood pressure were obtained on different days.

Three additional points deserve to be made. First, the white coat effect directly measured with continuous finger blood pressure recording is similar to the white coat effect previously documented through intra-arterial blood pressure monitoring.\(^\text{6,12}\) Thus, the white coat effect can also be precisely quantified with a noninvasive approach,\(^\text{19}\) allowing the direct investigation of a number of important features of this phenomenon that have so far remained unexplored (ie, differences among different hypertensive subgroups, persistence or attenuation with time or different antihypertensive treatments and prognostic significance). Second, the observation that the difference between clinic and daytime blood pressure does not reflect the white coat effect does not deny the pathophysiological and clinical importance of this finding in a hypertensive individual.\(^\text{20–22}\) It is important, however, that the mechanisms responsible for this difference are investigated by taking into account not only what increases clinic blood pressure but also what modulates daily life blood pressure. It is also important that its prognostic value is studied separately from the prognostic value of the white coat effect. Its definition as white coat hypertension should therefore be avoided because its origin is different, whereas the clinical significance of the true white coat phenomenon can now be directly investigated. Finally, studies on the clinical significance of the true white coat phenomenon should take into account that previous data obtained through intra-arterial blood pressure monitoring have shown that the blood pressure response to the physician’s visit does not correlate with the blood pressure responses to mental arithmetic, with the responses to other laboratory stressors,\(^\text{23}\) and with daily life blood pressure variability.\(^\text{24}\) Thus, hyperreactivity to an emo-
tional stimulus does not invariably mean a generalized hyperreactivity to stress.

References


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