Clinical Investigations

Relationship between Joint National Committee-VI Classification of Hypertension and Ambulatory Blood Pressure in Patients with Hypertension Diagnosed by Casual Blood Pressure

YASUYA INDEN, M.D., MAKOTO TSUDA, M.D.,* HIROSHI HAYASHI, M.D., HIROTO TAKEZAWA, M.D., SHIGEO IINO, M.D., TAKAHISA KONDO, M.D., YUKIHIKO YOSHIDA, M.D., MAKOTO AKAHOSHI, M.D., MASAYUKI TERASAWA, M.D., TERUO ITOH, M.D.,† HIDEHIKO SATTO, M.D., MAKOTO HIRAI, M.D.

Division of Cardiology, First Department of Internal Medicine, Nagoya University School of Medicine, Nagoya; *Division of Clinical Research, Cardiovascular Center, Aichi Prefectural Owari Hospital, Ichinomiya; †Cardiovascular Center, Nagoya Daini Red Cross Hospital, Nagoya, Japan

Summary

Background: White-coat hypertension has been diagnosed arbitrarily based on different criteria. In 1997, the Joint National Committee-VI (JNC-VI) reported a new classification of hypertension and strongly emphasized the importance of ambulatory blood pressure (ABP) monitoring. The report pronounced normal ABP values for the first time.

Hypothesis: The study's aim was to clarify the relationship between casual blood pressure (BP) and ABP of patients with essential hypertension in each stage of JNC-VI classification, and the prevalence of white-coat hypertension diagnosed by using JNC-VI normal ABP criteria.

Methods: Ambulatory blood pressure was monitored non-invasively in 232 patients with essential hypertension whose casual BP was $\geq 140/90$ mmHg. The patients were classified according to JNC-VI classification, and their casual BP was compared with ABP. The criterion of white-coat hypertension was defined as casual BP $\geq 140/90$ mmHg with normal ABP according to JNC-VI criteria ($< 135/85$ during daytime and $< 120/75$ during nighttime).

Results: Mean ABP increased as the stage advanced, and the differences between casual BP and ABP also increased.

There were considerable overlaps in the distribution of ABP among stages. The prevalence of white-coat hypertension was 13% overall: 30% of the patients with isolated systolic hypertension, 19% of those in stage 1, 10% in stage 2, and 4% in stage 3.

Conclusions: Classification of hypertension based on casual BP may not always correspond in severity to that based on ABP. Ambulatory blood pressure monitoring recommended by JNC-VI is very useful for the evaluation of hypertension to differentiate white-coat hypertension from true hypertension.

Key words: hypertension, ambulatory blood pressure, JNC-VI classification, white-coat hypertension

Introduction

We usually diagnose patients with hypertension by means of casual blood pressure (BP) at outpatient clinics and judge the severity of their hypertension, decide on treatment, and evaluate the effects of treatment by casual BP. Though we rely on casual BP in various clinical states, casual BP does not always reflect BP outside the clinic. The existence of white-coat hypertension, in which the resting BP is diagnosed as hypertension at an outpatient clinic, whereas the BP at home is normal, has been recognized to be more important than previously believed.^{1–3} Twenty-four-hour ambulatory blood pressure (ABP) monitoring is an extremely effective procedure for examining white-coat hypertension.^{4–6} The information obtained from ABP is very important for both diagnosis and treatment of hypertension.^{7–9} In addition, it is said that ABP correlates better than casual BP to the degree of target organ damage, which is a standard for deciding whether to institute antihypertensive treatment.^{7, 10–13} Prospective data relating to ABP suggest that patients in whom an elevated clinic BP is the only abnormality may have relatively low risk of morbidity.^{14–16}

Address for reprints:

Yasuya Inden, M.D.
Division of Cardiology
First Department of Internal Medicine
Nagoya University School of Medicine
65 Tsurumai-cho, Showa-ku
Nagoya 466-8550, Japan

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In 1997, JNC-VI classification guidelines for the diagnosis and treatment of hypertension were announced by the Joint National Committee.¹⁷ Under these guidelines, hypertension is defined as systolic blood pressure (SBP) of ≥ 140 mmHg, or diastolic blood pressure (DBP) of ≥ 90 mmHg. The degree of hypertension is classified into three stages; the necessity for treatment was emphasized even for isolated systolic hypertension (ISH). Furthermore, ABP monitoring is recommended more strongly in this report than in earlier reports. It was proposed for the first time that normal BP values taken by ABP monitoring were $< 135/85$ mmHg during daytime and $< 120/75$ during nighttime. There is a possibility that considerably many patients included in the category of white-coat hypertension may be diagnosed as having hypertension based on casual BP.

It is clinically important to make a correct diagnosis of white-coat hypertension, which has been diagnosed arbitrarily based on different criteria.¹⁸ In previous studies on white-coat hypertension, patients with mild hypertension have been investigated at the outpatient clinic.^{2, 19} However, it is not rare that some patients diagnosed with severe hypertension at the outpatient clinic show normal ABP. In order to clarify the relationship between casual BP and ABP values in patients of each stage classified by JNC-VI, and the frequency of white-coat hypertension in each JNC-VI classification, the present study investigated casual BP and ABP of patients living in large Japanese cities who were diagnosed with essential hypertension at hypertension clinics.

Methods

Most study patients were referred by personal physicians or by doctors engaged in mass screening in the communities. We investigated 232 patients with essential hypertension who visited the hypertension clinic of Nagoya Daini Red Cross Hospital and showed SBP ≥ 140 mmHg or DBP ≥ 90 mmHg in three separate measurements. There were 109 men and 123 women, with ages ranging from 18 to 80 years (mean age 54.2 years). Patients had either never taken anti-hypertensive drugs or such drugs had been discontinued more than 4 weeks previously.

On at least three separate occasions at an outpatient clinic, casual BP (the average of two measurements of resting BP) was obtained using a mercury sphygmomanometer after a 15-min rest in a seated position. The 24-h ABP was automatically measured noninvasively every 30 min for 25 h by a portable device (ABPM-630, Nihon Colin, Komaki, Japan).²⁰⁻²² The measurements began between 8:30 and 9:30 A.M. Criteria for deleting or editing the blood pressure readings have been previously described.^{7, 22, 23} The measurements were performed during normal daily activity on a weekday, and each subject was instructed to avoid bathing, napping, alcohol consumption, rigorous sports, or extraordinary mental stress.

Under ABP monitoring, the oscillometric method was used every 30 min during the day and night. To avoid artifact readings, we discarded the first two measurements obtained in the

first hour after device set-up. From the measurement data, the means for SBP and DBP were calculated for 24 h during the daytime (7:00 A.M.–11:30 P.M.) and nighttime (23:00 P.M.–6:30 A.M.).

Subjects were classified into four JNC-VI classification stages according to casual BP: ISH, and stages 1, 2, and 3. We compared ABP (24 h, daytime, and nighttime) among the stages and investigated the prevalence of ABPs. We also compared white-coat effect²⁴—that is, the difference between casual BP and ABP—among the stages. Using the normal BP values of ABP of JNC-VI, we also examined the distribution of patients with normal ABP (white-coat hypertension) among the classifications. White-coat hypertension was defined as both systolic and diastolic mean ABP $< 135/85$ mmHg during daytime and $< 120/75$ mmHg during nighttime while casual BP revealed hypertension according to JNC-VI. If either systolic or diastolic mean ABP exceeded the criteria, the patient was not diagnosed as having white-coat hypertension. Furthermore, we investigated white-coat hypertension diagnosed by daytime ABP only.

Statistical Analysis

Values are expressed as mean $\pm$ standard deviation. Significance of differences among groups was analyzed by Student's *t*-test or one-factor ANOVA when appropriate. Results expressed as proportions were analyzed by using the chi-square test and the relationships between continuous variables were assessed using Pearson's coefficient of correlation. A value of $p < 0.05$ was considered statistically significant in all tests.

Results

Based on the JNC-VI classification, the subjects were classified into four groups: ISH and three stages. The mean casual BP and ABP of the patients in each group are shown in Table I. Mean casual BP of the 232 subjects was $167 \pm 18/98 \pm 11$ mmHg. Mean casual SBP was lowest in stage 1; on the other hand, mean casual DBP was lowest in ISH. Although casual SBP in patients with ISH was significantly higher than that in stage 1 patients, there was no significant difference in 24-h ABP between the two groups. As the stage advanced from 1 to 3, 24-h ABP increased in both SBP and DBP. Daytime and nighttime ABP also increased as the stage advanced. In all stages, casual SBP was higher than 24 h, daytime or nighttime SBP, and daytime SBP was higher than nighttime SBP (Table I). The same relations were observed in DBP.

White-coat effects in each stage of JNC-VI classification are shown in Table II. White-coat effect of daytime SBP, measured as casual SBP $\pm$ daytime SBP, was 20 ± 20 mmHg overall; it was smallest in stage 1 (5 ± 14 mmHg) and greatest in stage 3 (31 ± 23 mmHg). White-coat effect of daytime DBP (casual DBP $\pm$ daytime DBP) was 9 ± 11 mmHg overall; it was smallest in ISH and increased as the stage advanced. White-coat effect based on 24-h ABP showed a distribution among stages similar to that calculated from daytime ABP.

TABLE I Blood pressure of patients in each stage of the JNC-VI classification

	Total	ISH	Stage 1	Stage 2	Stage 3
Number (%)	232	40 (17)	26 (11)	95 (41)	71 (31)
Age (years)	54 ± 12	57 ± 11	47 ± 13 ^a	56 ± 11 ^b	53 ± 12
Sex (male/female)	109/123	14:26	17:9	52:43	26:45
Casual SBP	167 ± 18	158 ± 12	147 ± 9 ^a	163 ± 10 ^b	185 ± 17 ^{a, b, c}
Casual DBP	98 ± 11	82 ± 5	93 ± 3 ^a	99 ± 5 ^{a, b}	108 ± 10 ^{a, b, c}
24-h SBP	143 ± 16	136 ± 14	136 ± 12	143 ± 15	149 ± 16 ^{a, b, c}
24-h DBP	86 ± 10	80 ± 7	83 ± 7	86 ± 9 ^a	89 ± 11 ^a
Daytime SBP	147 ± 16	140 ± 14	142 ± 12	147 ± 15	154 ± 17 ^{a, b}
Daytime DBP	89 ± 10	83 ± 8	87 ± 7	90 ± 9 ^a	93 ± 11 ^a
Nighttime SBP	133 ± 18	127 ± 18	124 ± 15	132 ± 18	139 ± 18 ^{a, b}
Nighttime DBP	78 ± 11	73 ± 8	75 ± 10	79 ± 11	82 ± 12 ^a

^ap < 0.05 versus ISH.^bp < 0.05 versus stage 1.^cp < 0.05 versus stage 2.

Values are expressed as means ± standard deviation.

Abbreviations: ISH = isolated systolic hypertension, SBP = systolic blood pressure (mmHg), DBP = diastolic blood pressure (mmHg).

The correlation between casual BP and white-coat effect in daytime was $r = 0.66$ ($p < 0.01$) for SBP and $r = 0.59$ ($p < 0.01$) for DBP (Fig. 1). Greater white-coat effect was observed in proportion to greater casual BP. Some patients (14% for SBP and 22% for DBP) had higher ABP than casual BP levels.

Figure 2 shows correlations between SBP and DBP in all patients. The correlation between SBP and DBP in casual BP was $r = 0.40$ ($p < 0.01$) (Fig. 2A), while its correlation in 24-h ABP was $r = 0.90$ ($p < 0.01$) (Fig. 2B). The scatter graph shows that distribution of 24-h ABP overlapped among JNC-VI stages. On the other hand, correlation between casual BP and 24-h ABP was $r = 0.33$ ($p < 0.01$) for SBP and $r = 0.45$ ($p < 0.01$) for DBP (scatter graph not shown).

Twenty-nine patients (13%) were considered to have white-coat hypertension by means of normal ABP of JNC-VI using both daytime and nighttime ABP (Fig. 3A): 12 (30%) of patients with ISH; 5 (19%) of those in stage 1; 9 (10%) in stage 2; and 3 (4%) in stage 3. Diagnosed according to daytime ABP only (Fig. 3B), 45 patients (19%) had white-coat hypertension: 14 (35%) of patients with ISH; 7 (27%) of those in stage 1; 16 (17%) in stage 2; and 8 (11%) in stage 3. According to

JNC-VI classification, the prevalence of white-coat hypertension was highest in patients with ISH according to either criteria, and it decreased as the stage advanced.

Discussion

The major finding of this study is that the evaluation of the severity of hypertension by casual BP does not always correspond to that by ABP, and that more than 13% of hypertensive patients were categorized as having white-coat hypertension by means of ABP recommended by JNC-VI.

In most cases seen at outpatient clinics, diagnosis and treatment of hypertension are based on casual BP. However, it is impossible to simply evaluate BP under the various conditions during 24 h from casual BP.¹⁻³ In contrast, ABP during normal daily activity can reflect BP more accurately in usual situations, including at nighttime during sleep.⁷

The Joint National Committee-VI classification was also based on casual BP, and in this report ABP monitoring was recommended for diagnosis of hypertension.¹⁷ We used ABP

TABLE II White-coat effect on patients in each stage of JNC-VI classification

	Total	ISH	Stage 1	Stage 2	Stage 3
24-h SBP	24 ± 10	22 ± 15	10 ± 14	20 ± 16	36 ± 23 ^{a, b, c}
24-h DBP	13 ± 11	3 ± 9	10 ± 8 ^a	13 ± 9 ^a	19 ± 11 ^{a, b, c}
Daytime SBP	20 ± 20	18 ± 15	5 ± 14 ^a	16 ± 16	31 ± 23 ^{a, b, c}
Daytime DBP	9 ± 11	0 ± 9	6 ± 8	9 ± 9 ^a	15 ± 11 ^{a, b, c}

^ap < 0.05 versus ISH.^bp < 0.05 versus stage 1.^cp < 0.05 versus stage 2.

Values (mmHg) are expressed as means ± standard deviation.

Abbreviations as in Table I.

FIG. 1 Correlation between casual blood pressure and white-coat effect (casual blood pressure – ambulatory blood pressure). (A) Relation in systolic blood pressure (SBP); (B) relation in diastolic blood pressure (DBP). Scatter graphs show all patients in this study. Symbols indicate blood pressure of patients in each stage of JNC-VI classification (see key in figure). Correlation in SBP was $r = 0.66$ ($p < 0.01$) and that in DBP was $r = 0.59$ ($p < 0.01$). In patients below the 0 line, daytime ambulatory blood pressure was higher than casual blood pressure.

for the investigation of patients with hypertension. Mean ABP during 24 h increased as the stage advanced. Nevertheless, there was considerable overlap in ABP among stages, based on casual BP (Fig. 2B). This indicates that the severity of hypertension cannot be efficiently evaluated using only casual BP. Casual SBP tends to be higher in patients with ISH compared with stage 1; however, this difference was not significant.

It has been reported that ABP during daytime was 20/10 mmHg lower than casual BP.²⁵ Our data revealed results that were very similar. White-coat effect increased as the stage of JNC-VI advanced in the present study, and the increase of white-coat effect was in accordance with the previous report using JNC-V classification.²⁶ Correlation between the casual BP and white-coat effect was high ($r = 0.66$). It may be clinically important to take the white-coat effect into consideration in the hypertension clinic, particularly when casual BP is very high.

White-coat hypertension is diagnosed arbitrarily based on different criteria. Pickering *et al.*² used the criteria that the upper limit of awake SBP/DBP was 134/90 mmHg, the 90th percentile of their distribution in a clinically normotensive population. White *et al.*⁷ defined normal daytime ABP as 130/80 mmHg. A meta-analysis of 23 studies indicated upper limits of normal mean daytime BP of 146/91 mmHg regardless of age and gender.²⁷ In this study, we diagnosed white-coat hypertension using both daytime and nighttime normal ABP in

accordance with the classifications of JNC-VI. According to these criteria, 13% of patients with hypertension were diagnosed as having white-coat hypertension. Diagnosis of white-coat hypertension by daytime ABP only was 19% overall; there was also a high frequency (33–35%) of white-coat hypertension in patients with ISH. The prevalence of white-coat hypertension diagnosed by ABP decreased as JNC-VI stage advanced. Compared with the previous report concerned with JNC-V stage,²⁶ the prevalence of white-coat hypertension in each stage was almost the same in the present study.

Conclusions

The present study shows that evaluation of the severity of hypertension by casual BP only is not always adequate. Ambulatory blood pressure measurements revealed that the distributions of ABP overlapped considerably among the JNC-VI stages based on casual BP. Using ABP values established as normal by JNC-VI, 13 to 19% of patients with hypertension were diagnosed as having white-coat hypertension by casual BP. Even in severe hypertension such as stage 3, some patients were diagnosed as having white-coat hypertension. Ambulatory blood pressure is an important clinical tool for reliable diagnosis of the severity of hypertension, especially for differential diagnosis of white-coat hypertension.

FIG. 2 Correlation between systolic (SBP) and diastolic blood pressures (DBP). (A) Relation to casual blood pressure; (B) relation to 24-h ambulatory blood pressure (ABP). Symbols indicate blood pressure of patients in each stage of JNC-VI classification (see key in figure). Correlation of all patients according to casual blood pressure was $r = 0.40$ ($p < 0.01$) and according to 24-h ABP was $r = 0.90$ ($p < 0.01$). ISH = isolated systolic hypertension.

FIG. 3 Prevalence of white-coat hypertension based on ambulatory blood pressure (ABP) according to JNC-VI classification. (A) Prevalence diagnosed by both daytime and nighttime ABP; (B) prevalence diagnosed by daytime ABP only. Prevalence was highest in patients with isolated systolic hypertension (ISH) and decreased as the stage advanced.

Appendix

The Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure¹⁷ provided JNC-VI classifications in 1997 as follows: High-normal (SBP 130–139 mmHg or DBP 85–89 mmHg), isolated systolic hyper-

tension (SBP ≥ 140 mmHg and DBP < 90 mmHg), stage 1 (SBP 140–159 mmHg or DBP 90–99 mmHg), stage 2 (SBP 160–179 mmHg or DBP 100–109 mmHg), stage 3 (SBP ≥ 180 mmHg or DBP ≥ 110 mmHg).

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