

Original Article

Clinic Blood Pressure Measurements Versus Ambulatory Blood Pressure Monitoring

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ABSTRACT

Objectives: To compare clinic (office) blood pressure (BP) measurement and ambulatory blood pressure monitoring (ABPM) in the clinical evaluation of hypertensive subjects.

Methods: Hundred middle aged and pharmacologically untreated hypertensive subjects were studied (80 men and 20 women). All subjects were referred from outpatient clinic in Farwania Hospital with BP greater than 140/90 mmHg. Resting ECG and echocardiography were done to assess left ventricular hypertrophy (LVH). In order to exclude patients with ischemia an exercise ECG was done. Ambulatory blood pressure was recorded with an auscultatory device.

Results: There was a non-significant difference between the three clinical sessions in the measurement of the office systolic and diastolic BP readings, (P= NS). There was no significant intra-recording variation between the first and the second ABPM recordings when considering awake

and asleep maximum SBP, minimum systolic BP, maximum diastolic BP and minimum diastolic BP (P = NS). Stepwise logistic analysis showed that ambulatory sleeptime and 24-hour systolic blood pressure had a significant relation to the presence of left ventricular hypertrophy (P < 0.05). There was a good agreement between clinic BP readings and ambulatory daytime systolic and diastolic BP recordings as there was a good distribution of values between upper and lower limits of agreement (mean \pm 2SD). There was a significant correlation between office systolic BP readings and awake systolic ABPM recordings (r = 0.954, P < 0.01).

Conclusion: Measured by non-physicians, clinic BP is as reliable as ambulatory BP monitoring in the clinical evaluation of untreated hypertensive patients. Asleep ABP, 24-hour ambulatory BP and daytime systolic BP variability were also shown to be good indicators of left ventricular hypertrophy.

KEYWORDS: ambulatory blood pressure monitoring, blood pressure, left ventricular hypertrophy

INTRODUCTION

Classification of hypertensive patients by conventional measurement techniques may lead to over diagnosis and over treatment of hypertension^[1]. Clinic (office) blood pressure (BP) may not necessarily represent an individual's usual BP level^[2]. Evidence of the risk of arterial hypertension and the benefits of its treatment are based on casual blood pressure measurements^[3,4]. Blood pressure can be measured in different environments (clinic, home, and work place) by different personnel (physician, nurse or patient) and with a conventional sphygmomanometer or ambulatory BP devices^[5]. Several studies suggest that clinic BP is higher than self-measured BP or ambulatory BP^[6]. Blood pressure measured by a physician tends to be higher than BP measured by a non-physician^[7,8]. Ambulatory blood pressure monitoring (ABPM) has aided our understanding of BP circadian rhythm and has identified differences in BP rhythms in several population subgroups (e.g., less than expected BP fall occurred during sleep also called non-dipping in blacks, and in people with Cushing syndrome, congestive heart

failure and type 2 diabetes)^[9,10]. ABPM has been shown effective in testing antihypertensive drugs^[3]. Compared with standard BP measurements it simplifies the determination of the time of a drug's peak and trough effects^[11] and offers less within subject test-retest variability than casual office readings^[12].

Aim of study:

1. To compare office BP measurements at outpatient clinic with ABPM in the clinical evaluation of untreated hypertensive patients
2. To assess of the reliability and validity of ABPM for recording of sleeping time BP.
3. To quantify their relation to the left ventricular hypertrophy.

SUBJECTS AND METHODS**Study subjects:**

One hundred and forty patients were included in the study. All patients were referred by their physicians to the non-invasive cardiac laboratory, medicine department, Farwania Hospital between August 2001 and August 2002. Twenty five subjects

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(25%) were referred due to high blood pressure and ECG criteria of left ventricle hypertrophy, 25 subjects (25%) were referred to report as dippers or non-dippers and 29 subjects (29%) were referred to confirm casual blood pressure measurement. Thirty-three subjects (33%) were discovered accidentally during routine examination, 21 subjects (21%) presented for preoperative assessment for elective non-cardiovascular surgery.

Exclusion criteria included patients with coronary artery disease, diabetes mellitus, cerebrovascular disease, significant valvular disease and pregnant women. Exclusion was based on medical history, physical examination, routine biological chemical tests, exercise ECG and echocardiography.

There were two groups:

Group I: included 40 normotensive patients (30 male and 10 female). Group II: included 100 pharmacologically untreated hypertensive patients (80 male and 20 female) with clinic systolic and/or diastolic blood pressure greater than 140 and 90 mm Hg, respectively.

Blood pressure measurements:

Clinic BP was measured by a trained nurse. Mercury sphygmomanometer was used to measure systolic and diastolic BP (in mm Hg). At least two measurements were recorded between 8 am and 11 am with the patients in a sitting position with the legs uncrossed and the feet on the floor. A cuff with a bladder width of 15 cm was used. Patients were requested to refrain from heavy exercise in the morning and to avoid cola drink, coffee, tea and smoking for at least one hour before the measurement. BP was measured after the patients had rested for 15 minutes. The last five minutes of rest were spent in the measurement room with the cuff around the right upper arm. Cuff inflation pressure was then determined by palpating the disappearance and appearance of the radial pulse. BP was recorded twice, with approximately a 2-minute interval. Duplicate measurements were done in three separate sessions within three weeks. Office BP was determined as the mean of the three duplicate BP measurements.

Ambulatory blood pressure was recorded with an auscultatory device (Accutracker II) by using a special modified microphone. Correct positioning of the microphone was done by palpating the brachial artery of the left arm. Ambulatory BP was recorded during daytime (6 am to 10 pm) at one-hour intervals and during nighttime (10 pm to 6 am) at 2-hour intervals. Sleep time was identified by the patients' diary. Twenty four-hour BPs were calculated: day time, night time, awake and asleep

BPs. Maximum, minimum, average and standard deviation (SD), mean arterial pressure, heart rate, blood pressure load of day time and night time systolic and diastolic blood pressure and load were calculated.

BP data were edited automatically and readings with a quality failure code (ECG connection giving erratic heart beats or missing them completely; Korotkoff sounds that were too weak or not detected, loose cuff or air leak) were rejected.

Blood pressure load is the percentage of all systolic and diastolic BP recordings that exceed thresholds of 140/90 mm Hg^[6]. Pulse pressure was calculated as the difference between systolic and diastolic blood pressure. Mean blood pressure was calculated as diastolic blood pressure plus 1/3 pulse pressure^[6].

Blood pressure variability:

We focused on BP variability every 60 minutes, that is short-term variability rather than circadian BP variation. Short term BP variability (every 60 minutes) was calculated as the SD of daytime ambulatory blood pressure^[7].

Design of the study:

All patients were informed to fill the diary form which included the time, date, the patients symptoms, activities and the sleeping time. (Table 1) Our protocol was designed to record 24-hour ambulatory blood pressure twice with a one-week interval. Readings with a quality failure code were rejected (Table 2).

Echocardiographic study:

Two-dimensional and M-mode echocardiography were performed for all patients of the study with the use of a Toshiba Power Vision and a 3.5 MHz phased array transducer. All echocardiographic studies were performed by the same cardiologist. Measurements were performed according to the recommendations of the American Society of Cardiology^[13]. The leading edge to leading edge convention was used. Left ventricular dimensions were measured at or immediately below the tips of mitral leaflets and averaged over five heart cycles. LVM and LVM index were calculated.

Statistical analysis:

Statistical values are given as mean \pm standard deviation (SD). The ANOVA test was used to compare the means of a quantitative variable between the clinic, ambulatory awake, asleep and 24-hour BP recordings. A P-value of < 0.05 was considered statistically significant and P-value of < 0.01 was considered statistically highly significant. Stepwise multivariate regression models were used to identify possible independent variables associated with left

Table 1

Example of the patient's diary form to fill in whenever the cuff inflates

Date/ Time	Activity	Symptom
12-8-2002 11 am	sitting	none
12-8-2002 01 pm	driving	none
12-8-2002 03 pm	eating	headache

Table 2

Causes of rejected readings with a quality failure code in 12 patients

Difficulty	n	Time	Gender
Poor ECG electrode connection	4	asleep	4F
Missed heart beats	2	awake	1F/1M
Loose cuff	5	asleep	3F/2M
Air leak	1	asleep	1M

F=female, M=male, n= number

Table 3

Intra-recording variation of awake ambulatory blood pressure among 40 hypertensive patients

	Maximum Systolic BP	Minimum Systolic BP	Maximum Diastolic BP	Minimum Diastolic BP
First Recording	168.4 ± 5.34	150.9 ± 7.42	108.8 ± 4.41	98.5 ± 3.83
Second Recording	161.4 ± 5.91	155.6 ± 5.94	102 ± 3.72	94.7 ± 2.64
P-value	NS	NS	NS	NS

Table 4

Intra-recording variation of asleep ambulatory blood pressure among 40 hypertensive patients

	Maximum Systolic BP	Minimum Systolic BP	Maximum Diastolic BP	Minimum Diastolic BP
First Recording	145.5 ± 3.14	130.4 ± 7.42	98.6 ± 2.11	92.5 ± 2.81
Second Recording	140.2 ± 4.21	125.5 ± 5.94	95.3 ± 4.42	87.1 ± 3.14
P-value	NS	NS	NS	NS

Table 5

Demographic data in both groups of the study

Variables	Group I n = 40	Group II n = 100	P-Value
Age (years): mean ± SD	55.34 ± 5.81	53.27 ± 6.43	NS
Gender (M/F)	30M/10F	80M/20F	NS
Smoking status: n.(%)	20 (50%)	40 (40%)	NS
Cholesterol (mmol/dl)	6.03 ± 1.57	6.32 ± 1.42	NS
Triglycerides (mmol/dl)	3.12 ± 1.86	2.83 ± 1.48	NS
BMI (kg/m ²)	30.32 ± 4.21	32.11 ± 3.34	NS

ventricular hypertrophy (LVH). The strength of the association with LVH is presented as a 95% confidence intervals. Potential confounding clinical variables were entered as independent variables. The agreement between mean daytime ambulatory blood pressure and clinic (office) BP measurements were

evaluated by using the method of Bland and Altman^[4]. The mean of the difference and SD were calculated to obtain limits of agreement. Upper limit of agreement = mean of difference + 2SD and lower limit of agreement = mean of difference - 2SD. For a good agreement at least 95% of values must lie within the limits of agreement.

Simple linear regression (least-square method) was used for correlation of the parameters of the study: (using $y = ax + b$, where $y = \text{ABPM}$, $x = \text{clinic BP}$, $a = \text{slope}$ and $b = \text{intercept}$).

RESULTS

Only 40 hypertensive patients successfully completed the two recordings. There was an insignificant difference between the patients of group I and those of group II when considering age, gender, smoking status, serum cholesterol, serum triglycerides and body mass index [55.34 ± 5.81 versus 53.27 ± 6.43 years, $P = \text{NS}$, 30 males/10 females versus 80 males / 20 females, $P = \text{NS}$, 20 (50%) versus 40 (40%), $P = \text{NS}$, 6.03 ± 1.57 versus 6.32 ± 1.42 mmol/dl, $P = \text{NS}$, 3.12 ± 1.86 versus 2.83 ± 1.48 mmol/dl, $P = \text{NS}$ and 30.32 ± 4.21 versus 32.11 ± 3.34 kg/m², $P = \text{NS}$, respectively; (Table 3).

Among 40 hypertensive patients there was no significant intra-recording variation between the first and the second ABPM recordings with respect to awake and asleep maximum SBP, minimum systolic BP, maximum diastolic BP and minimum diastolic BP ($P = \text{NS}$); (Table 4 & 5). With regards to the confounders that may affect the ambulatory BP recording, there was no change in daily life style and activities during the first and the second ABPM recordings and there was no significant difference with respect to the time of awake and asleep BP between the two ABPM recordings.

We found that there was no significant difference between clinic and ambulatory awake, asleep and 24-hour heart rate recordings (79.7 ± 6.2 versus 75.4 ± 7.7 , 77.3 ± 6.9 and 84.5 ± 8.2 beat/minute respectively, $P = \text{NS}$). There was no significant difference between clinical and awake systolic AMBP (165.43 ± 7.9 versus 155.83 ± 7.3 mm Hg respectively, $P = \text{NS}$) but there was a significant increase in clinical systolic BP compared to asleep and 24-hour ambulatory systolic BP (165.43 ± 7.9 versus 135.47 ± 5.9 and 145.66 ± 5.3 mmHg respectively, $P < 0.05$). There was no significant difference between clinical and awake ambulatory diastolic BP (100.33 ± 3.9 versus 95.03 ± 2.4 mm Hg respectively, $P = \text{NS}$) but there was a significant increase in clinic diastolic BP than asleep and 24-hour ambulatory diastolic BP (100.33 ± 3.9 versus 90.15 ± 6.2 and 92.16 ± 5.2 mmHg respectively, $P < 0.05$); (Table 6).

Table 6

Clinic and Ambulatory blood pressures and Heart rates (mean \pm SD)

Variables	HR (bpm)	SBP (mmHg)	DBP (mmHg)
Clinic BP	79.4 \pm 6.2	165.43 \pm 7.9	105.33 \pm 3.19
Awake ABP	75.4 \pm 7.7	158.83 \pm 7.3	98.03 \pm 2.4
Asleep ABP	67.3 \pm 6.9	135.47 \pm 5.9	90.15 \pm 6.2
24-hour ABP	76.5 \pm 8.2	145.66 \pm 5.3	92.16 \pm 5.2

ABP=ambulatory blood pressure, bpm=beat per minute, DBP=diastolic blood pressure, HR=heart rate, SBP=systolic blood pressure

Table 7

Stepwise logistic analysis of patients with versus those without left ventricular hypertrophy when considering clinic systolic blood pressure, ambulatory systolic blood pressure monitoring and blood pressure variability

Variables	Regression Coefficient	Standard Error	P Value
Clinic BP	0.0643	0.0582	NS
Awake ABP	0.0875	0.0236	NS
Asleep ABP	0.2784	0.0703	<0.05
24-hour ABP	0.1976	0.0685	<0.05
Daytime SBPV	0.1875	0.0406	<0.05
Nighttime SBPV	0.2181	0.0797	NS
Daytime MBPV	0.1276	0.0486	NS
Nighttime MBPV	0.0633	0.0362	NS

No. of observations = 100, ABP=ambulatory blood pressure, MBPV=mean blood pressure variability, SBPV=systolic blood pressure variability

Stepwise logistic analysis revealed that the ambulatory asleep ABP, 24-hour systolic ABP and daytime systolic ABP variability had a significant relationship to the presence of left ventricular hypertrophy (LVH). Awake ABP, clinic BP, nighttime systolic BP variability, daytime mean BP variability and nighttime systolic BP variability had no significant relation to the presence of LVH (Table 7). The age, gender and BMI had no significant relation to the presence of LVH ($R = 0.2621, 0.1645$ and 0.2258 , 95% CI = $0.654 - 1.831, 0.744 - 1.032$ and $0.988 - 1.876$, respectively, $P = NS$).

There was a good agreement between clinic and daytime systolic and diastolic BP since there was a good distribution of values between upper and lower limits of agreement, 22.6 and -18.4 mmHg respectively for systolic BP, and 12.3 and -8.6 mmHg for diastolic BP, (Fig. 1 & 2).

There was an insignificant difference between the patients of the two groups when considering office systolic and diastolic BP and ambulatory awake, asleep and 24-hour systolic and diastolic BP monitoring, ($P = NS$), (Fig. 3 & 4).

There was a non-significant difference between the three clinical sessions when measuring the office systolic and diastolic BP readings, ($P = NS$), (Fig. 5).

There was a significant correlation between

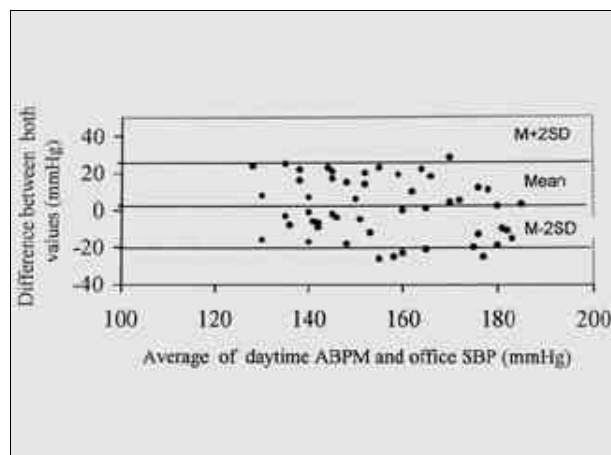


Fig. 1: Plot panel of the systolic blood pressure values obtained by office BP measurement and ambulatory BP monitoring versus the difference between both values.

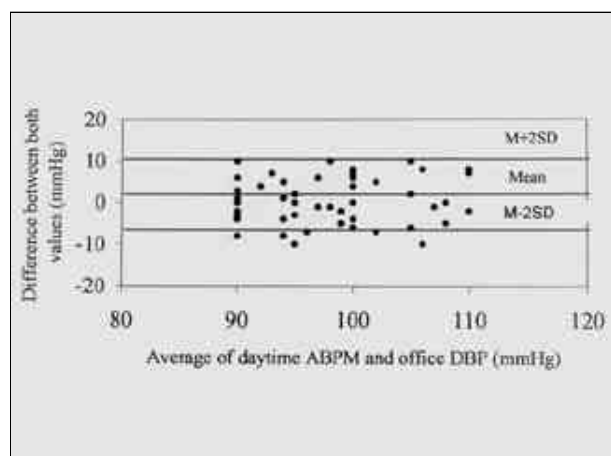


Fig. 2: Plot panel of the diastolic blood pressure values obtained by office BP measurement and ambulatory BP monitoring versus the difference between both values.

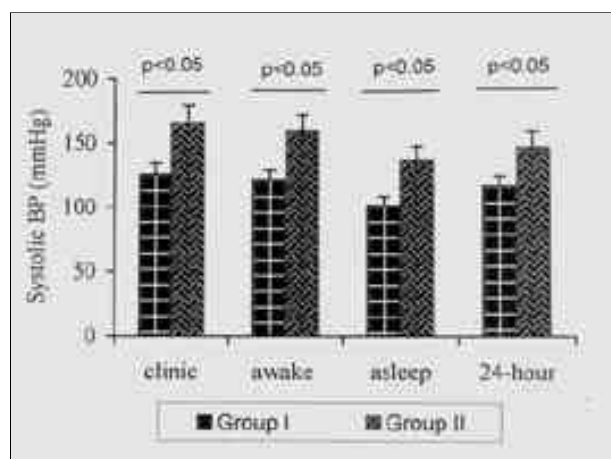


Fig. 3: Systolic clinic BP, awake, asleep and 24-hour ambulatory BP in group I & II

office (clinic) systolic BP and ambulatory awake systolic BP ($r = 0.954, P < 0.01$), (Fig. 6).

Predicted awake systolic ABPM = $25 + 0.786 X$, where X is the casual clinic systolic BP reading.

DISCUSSION

In this study, we observed that inspite of the lower

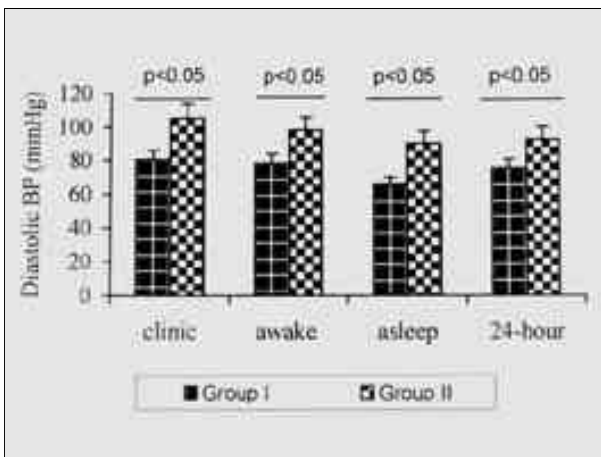


Fig. 4: Diastolic clinic BP, awake, asleep and 24-hour ambulatory BP in group I & II

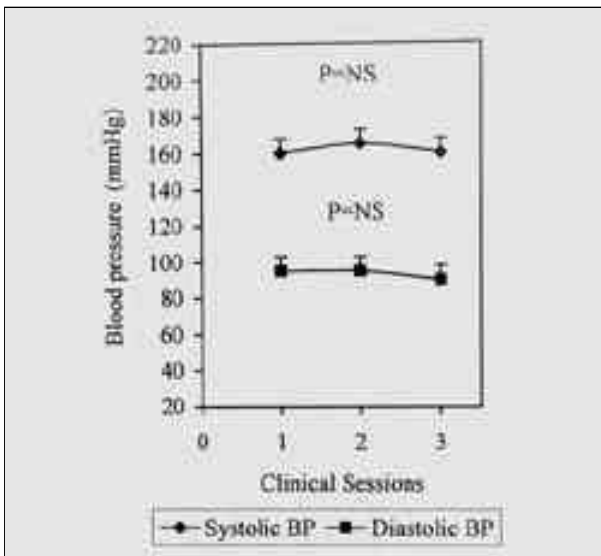


Fig. 5: Mean ± SD values of the 3 office blood pressure readings

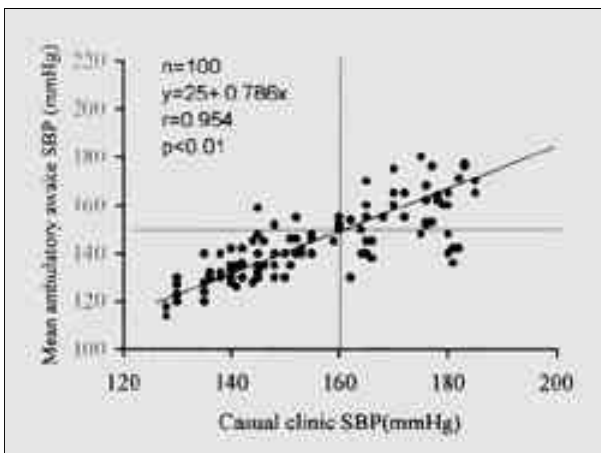


Fig. 6: Scatter diagram and matching regression line, correlation between clinic and ambulatory awake systolic BP

24-hour ambulatory blood pressure monitoring as opposed to the casual office BP as measured by physician and nurse, there was an agreement between awake ambulatory BP and casual clinic BP. We observed that ambulatory BP values were identical to those of ambulatory BP population

studies in Ireland, Belgium and Japan except for the Danish study^[7]. In the Danish study a higher 24-hour systolic BP was observed which was possibly related to the colder climate and older age of participants. Pearce and his colleagues found that ambulatory daytime systolic BP was slightly higher than clinic BP as they made population derived comparisons between ambulatory and clinic BPs. The correlation between clinic and ambulatory BP were relatively high and in agreement with studies based on a large number of patients^[7] or on multiple clinic BP measurements^[15]. In contrast to earlier studies, BP decreased slightly with increasing number of clinic measurements sessions. Within measurement sessions BP differences between the first and second readings were smaller than previously reported^[16,17]. Compared with ambulatory BP, office BP would have been higher, if it had been measured with cuffs with the same bladder widths as used in ambulatory BP monitoring^[18].

In some hypertensive individuals, the elevation of clinic BP is not accompanied by a similar BP elevation outside the clinical environment i.e. at home or over 24-hours. This is believed to be reflective of an excessive emotional response to BP measurements by a doctor or a nurse which has led to this condition to be termed “white coat hypertension”^[19]. The standard definition of white coat hypertension is an elevation of clinic BP with a normal daytime ambulatory BP profile^[20]. Data on whether white coat hypertension is clinically relevant however, is more controversial than those on the day/night BP difference. First, the prevalence of white coat hypertension in the population is not yet precisely established. It is now clear that several earlier studies have probably overemphasized the frequency of this phenomenon because of their failure to take into account that the cut-off value dividing ambulatory BP normality and abnormality is much lower than the corresponding office BP value i.e. much lower than 140/90 mmHg^[21]. Second, there is reason to believe that the difference between clinic BP and ambulatory BP monitoring may depend on several factors other than the pressure response to BP measurements in the clinical environment. This reflects the term white coat hypertension to identify that the office BP is higher than the average day/time ambulatory BP can be a misnomer. The office and ambulatory BP difference is not accompanied by a similar difference in heart rate as it should be if the greater office BP values were due to an emotional stimulus. It is greater in aged subjects in whom the haemodynamic response to emotions is not greater. It is negatively related to ambulatory BP monitoring and unrelated to the true BP response to the doctor as measured in

patients undergoing a medical visit while under continuous non-invasive BP monitoring^[22].

Several studies have examined association between left ventricular hypertrophy and blood pressure^[23,24]. The correlations with ambulatory BP have usually been found to be stronger than office BP. The findings, however, are less consistent in studies with a large number of patients and/or based on multiple office BP measurements^[23,24]. In this study, when compared with clinic (office) BP, ambulatory BP recording variables (sleep time and mean 24-hour systolic BP) were associated with left ventricular hypertrophy. Mancia and Parati^[25] have observed that in hypertensive subjects with left ventricular hypertrophy, the difference between clinic BP and ambulatory BP is variably attenuated by long-term treatment. This attenuation does not play any role in the regression of left ventricular hypertrophy. The latter depends exclusively on the treatment induced reduction in ambulatory BP.

ABPM is applicable in clinical practice and the indications to ambulatory BP monitoring according to World Health Organization and International Society of Cardiology guidelines are unusual variability of BP over the same or different visits, office hypertension in subjects with low cardiovascular risk, symptoms suggesting hypotensive episodes and hypertension resistant to drug treatment. Physicians should be left free to decide when ambulatory BP monitoring should be performed, keeping in mind that they may increase the number of clinical visits and by obtaining at each visit multiple BP measurements^[25].

Limitations of the study:

1. Heart rate variability as a marker of autonomic nervous system function was not included in the study due to difficulty to assess HR variability by ambulatory ECG recorder at the same time of BP recording.
2. Relatively small number of patients.
3. Only mercury sphygmomanometer is available in outpatient clinic.
4. Assessment of other end organs was not included in the study.
5. Only 40 patients out of the study sample had successfully completed the two ABP recordings to assess the validity and reliability of ABPM for recording sleeping BP.
6. Ten patients out of twelve patients were excluded from the study due to rejected readings with quality failure code or rejected recordings due to difficulties occurred during sleep time.
7. Self BP measurement and home BP measurements were not included in the study design.

CONCLUSION

BP measured in the office by non-physician, is as reliable as ambulatory BP monitoring in the clinical evaluation of untreated hypertensives. Sleep time BP, 24-hour ambulatory BP monitoring and daytime systolic BP variability are a good indicators for left ventricular hypertrophy. Further prospective studies are needed to assess reliability and validity of ABPM for recording of sleep time BP.

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