

Study of home-monitored night blood pressure and its correlation with left ventricular hypertrophy in treatment-naive hypertensive patients

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INTRODUCTION 24-hour ambulatory blood pressure (BP) monitoring is a well-validated tool that can reveal the patient's nocturnal dipping pattern. However, to the best of our knowledge, the role of home BP monitoring in identifying nocturnal dipping has not been studied.

METHODS We evaluated the nocturnal BP of 30 treatment-naive subjects using a home BP monitoring device. BP measurements were taken once during the daytime and once at night (three hours after sleep) by a blinded observer. Readings were correlated with left ventricular mass index.

RESULTS Night BP measurements were significantly lower in subjects without left ventricular hypertrophy (LVH) as compared to those with LVH, while the daytime readings were not significantly different between the two. The mean dips in nocturnal systolic and diastolic BP were $1.92\% \pm 6.89\%$ and $-0.55\% \pm 14.31\%$, respectively, in subjects with LVH. The corresponding values were $12.96\% \pm 6.16\%$ and $11.36\% \pm 11.90\%$ in those without LVH. The correlation between left ventricular mass index and night BP readings was statistically significant (systolic $r = 0.66$, $p < 0.001$; diastolic $r = 0.496$, $p < 0.005$).

CONCLUSION Nocturnal BP measurement using a home BP monitoring device may be a reliable and cost-effective method for detecting early signs of end-organ involvement such as LVH in hypertensives, especially in a resource-limited setting.

Keywords: ambulatory blood pressure monitoring, home blood pressure monitoring, left ventricular hypertrophy
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INTRODUCTION

Blood pressure (BP) during sleep may be one of the best variables for predicting target organ damage and prognosis, since it represents the basic 'unstimulated' BP as against BP measured in a seated and awake position.⁽¹⁾ BP recorded in a clinic is characterised by random and systematic errors related to the patient's reaction. Home blood pressure monitoring (HBPM) and 24-hour ambulatory blood pressure monitoring (ABPM), however, do not have these limitations and are supported by international hypertension management guidelines.⁽²⁾ Although the potential benefit of HBPM was known many years ago, its widespread acceptance occurred after automatic equipment based on an oscillatory method of recording BP was developed.⁽²⁾ Compared to clinic BP, ABPM is more objective and has been found to show a better correlation to target organ damage, since it can detect a dip in BP at night.⁽³⁾ HBPM is low cost and convenient to use, and measurements can be repeated without limit. It also empowers the patients and promotes the involvement of patients in their own care.⁽²⁾

Compared with HBPM, there is a greater bulk of data supporting the use of ABPM to optimise the management of the hypertensive patient.⁽¹⁾ Studies that compared the prognostic value of daytime BP with that of night-time BP inevitably found the latter to be superior for predicting prognosis.⁽¹⁾ Furthermore, daytime BP does

not add prognostic precision to the information provided by night-time BP. Until now, 24-hour ABPM has been the only reasonable and established way to measure night-time BP and day-night changes in BP. While 24-hour ABPM has been indicated in the initial evaluation of untreated subjects, the role of HBPM has been restricted to long-term assessment of hypertensive subjects.⁽³⁾ Although the relation between non-dipping of nocturnal BP and left ventricular mass is well established using 24-hour ABPM, the role of HBPM for night BP recording to detect dipping of BP has not been explored. Although some modern instruments for HBPM can be configured to take BP measurements at night,⁽⁴⁾ their clinical use to refine organ damage prediction and stratification has not been investigated.⁽¹⁾ Hence, this study aimed to evaluate the nocturnal BP of treatment-naive subjects using an electronic HBPM device and to correlate the data with left ventricular mass index (LVMI).

METHODS

A total of 30 consecutive hypertensive patients from the outpatient department were studied within a month of their diagnosis. The diagnosis of hypertension was made as per the JNC7 criteria. Subjects with a history of diabetes mellitus, secondary hypertension, congestive heart failure, myocardial infarction and valvular heart disease or coronary graft were excluded from the study. The study

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protocol was reviewed and approved by the institutional ethics committee. All subjects gave written informed consent prior to their inclusion in the study.

BP was measured using the Omeron HEM 780 electronic BP monitoring apparatus (Omron, Yamshita, Japan). BP measurements were taken in the daytime after 5–10 minutes in a resting state and again at night (three hours after sleep) at the patient's house by an attendant who was blinded to all other measurements. The attendant was trained in the procedure of recording BP using an electronic apparatus. The cuff was tied to the arm before the patient went to sleep. The attendant then connected the tube of the cuff to the electronic BP recording device three hours after the patient had gone into sleep. The recording was activated without disturbing the patient's sleep. The attendant taking the BP and the echocardiographer were both blinded to the patient's previous BP status or readings and other parameters being measured. Height and weight were also measured, and the body surface area (BSA) was calculated using the formula:⁽⁵⁾ $BSA (m^2) = 0.007184 \times \text{Height (cm)}^{0.725} \times \text{Weight (kg)}^{0.425}$. Left ventricular mass (LVM) was measured by echocardiography. LVMI was obtained by dividing the LVM by the BSA.⁽⁶⁾ For Indian population, the upper limit of normal for LVMI was 116 g/m² and 104 g/m² for men and women, respectively.⁽⁷⁾

The mean values of BP were compared using student's *t*-test, and the findings were correlated to LVMI by Pearson's coefficient. 95% confidence intervals (CI) were calculated. Receiver operating characteristic (ROC) curves were analysed in order to evaluate the diagnostic capabilities of various BP measurements to predict left ventricular hypertrophy (LVH). Data was analysed using the Statistical Package for the Social Sciences version 11.5 (SPSS, Chicago, IL, USA). A *p*-value < 0.05 was considered to be statistically significant.

RESULTS

A total of 30 treatment-naive subjects were studied (21 male and nine female). The study was conducted in the west coast of South India, and all subjects belonged to the same race. Age, daytime and night-time systolic and diastolic BP, as well as the quantum of dipping in the two groups, were studied (Table I). Echocardiography revealed 16 subjects with LVH. The mean systolic BP recorded using the sphygmomanometer in the outpatient department at the time of diagnosis was 144.88 ± 9.27 mmHg in those with LVH, as compared to 145.92 ± 11.76 mmHg in those without LVH (*p* = 0.79). Diastolic BP was 84.94 ± 6.81 mmHg in patients with LVH compared to 83.7 ± 9.89 mmHg in those without LVH (*p* = 0.69).

The daytime systolic and diastolic BP did not differ significantly between subjects with LVH and those without LVH, whereas night-time systolic and diastolic BP were significantly reduced in subjects without LVH. Correlation was statistically significant between systolic BP recorded in the night and LVMI (*r* = 0.66, *p* < 0.001, 95% CI 0.40–0.83). Positive correlation was also observed between diastolic BP recorded in the night and LVMI

Table I. Blood pressure and percentage dip in subjects with and without left ventricular hypertrophy.

Characteristic	Mean ± SD		p-value
	LVH (n = 16)	No LVH (n = 14)	
Age (yrs)	60.81 ± 10.97	61.64 ± 11.95	0.84
Systolic BP (mm Hg)			
Daytime	145.88 ± 10.52	144.86 ± 11.63	0.8031
Night-time	143.00 ± 13.62	126.07 ± 13.53	0.002
Diastolic BP (mm Hg)			
Daytime	83.00 ± 9.30	83.00 ± 10.50	1.000
Night-time	82.94 ± 11.53	72.93 ± 9.16	0.0145
Systolic dip (%)	1.92 ± 6.89	12.96 ± 6.16	0.0001
Diastolic dip (%)	-0.55 ± 14.31	11.36 ± 11.90	0.0002

SD: standard deviation; LVH: left ventricular hypertrophy; BP: blood pressure

(*r* = 0.496, *p* < 0.005 95% CI 0.17–0.73). There was, however, no significant correlation between LVMI and BP recorded during the daytime. The area under the ROC curve (AUROC) for systolic dip in BP was 0.915 (*p* < 0.001, 95% CI 0.807–1.023), and that for diastolic dip in BP was 0.741 (*p* < 0.03, 95% CI 0.557–0.925). On studying the dipping pattern with the coordinates of the ROC curve, the systolic BP dip of 9% yielded very good sensitivity and specificity (86% and 88%, respectively) for identifying LVH. Based on this cut-off value, 14 subjects had dipping of the systolic BP at night, and 16 did not. While 87.5% (14/16) of the non-dippers had LVH, only 14.3% (2/14) of the dippers had it. A diastolic BP dip of 7% yielded 71% sensitivity and 75% specificity for LVH.

DISCUSSION

LVH is an important sign of target organ involvement, indicating high cardiovascular risk. Office BP does not show a strong correlation with LVH as compared to out-of-office recordings, whereas BP recorded during sleep appears to be reliable in predicting target-organ damage.⁽¹⁾ Most studies that have examined the association between LVH and BP have found stronger correlations with ambulatory BP than with clinically recorded BP due to its ability to detect nocturnal dip. Although HBPM has been used during the night to record blood pressure,⁽⁴⁾ its clinical use to improve organ damage prediction has not been studied. In this study, we recorded night-time BP using an electronic HBPM device and evaluated its correlation with LVMI. Our study revealed that BP recording at night using an electronic equipment in the home environment yields vital data regarding LVH, an important indicator of target organ involvement. Night-time BP recorded at home was significantly lower in subjects without LVH compared to those with LVH, while their daytime readings were not statistically different. Systolic BP recorded at night showed statistically significant correlation with LVMI.

The 'dippers/non-dippers' classification was first introduced by O'Brien et al.⁽⁸⁾ Non-dippers are generally defined as subjects whose reduction in BP is less than a given percentage from day to night, whereas the subjects not falling under this category are classified as dippers. ROC analysis provides a useful means to assess the diagnostic accuracy of a test, and the performance of a

diagnostic variable can be quantified by calculating the AUROC. The AUROC curve of 0.915, ($p < 0.001$, 95% CI 0.807–1.023) observed in this study suggests that systolic dip measured by home BP recording at night appears to be a fairly accurate diagnostic test for LVH. ROC curve analysis found that a systolic dip of 9% yielded good sensitivity and specificity (86% and 88%, respectively) for predicting LVH. A diastolic dip of 7% yielded 71% sensitivity and 75% specificity, respectively. Hence, identifying 'non-dippers' with HBPM among treatment-naive subjects would help to pinpoint high-risk individuals. Another important observation was the phenomenon of reverse dip, characterised by higher night recording than day recording, as seen in some subjects. All seven individuals with systolic reverse dip had LVH.

Although it is well recognised that hypertension leads to LVH, there is a poor correlation between office recordings of BP and LVMI, whereas the average 24-hour BP and night BP recorded by 24-hour ABPM have shown good correlation.^(9,10) In one study, LVMI was positively correlated to the average level of the 24-hour systolic BP, night-time systolic BP and night-time diastolic BP ($r = 0.183$, $p < 0.05$; $r = 0.275$, $p < 0.01$; $r = 0.243$, $p < 0.05$, respectively).⁽¹⁰⁾ Our results, obtained with HBPM, were in line with these observations done with ABPM. There was no correlation between LVMI and daytime recording, whereas systolic and diastolic recordings with HBPM done at night had significant positive correlation with LVMI ($r = 0.66$, $p < 0.001$, $r = 0.496$, $p < 0.005$ respectively). Furthermore, the correlation coefficients were better than the reported values for ABPM.

The long-term follow-up of the PAMELA sample also provides evidence for the superiority of systolic over diastolic BP and of night-time over daytime values.⁽¹¹⁾ This may be due to the fact that indirect methods for measuring BP are more accurate for systolic than for diastolic values, particularly with devices based on an oscillometric method. It may also be a reflection of the prognostic superiority of systolic over diastolic BP, as shown by epidemiological studies.⁽¹¹⁾ The prognostic value of daytime BP may be reduced by the variability of BP, which is much more pronounced during the day than during the night. Moreover, the reduction of arteriolar tone observed during the night may also allow for greater transmission of BP values from the large central arteries to microcirculation, thus enhancing target organ damage.⁽¹¹⁾

Studies have been conducted on the role of HBPM in detecting white coat hypertension and masked hypertension. However, daytime self-measurement of BP has not been found to be a better guide to antihypertensive drug treatment than conventional BP measurement at the doctor's office in a randomised and controlled trial that compared office and home BP for the initiation and titration of antihypertensive drug treatment.⁽¹²⁾ While we observed that daytime self-recording did not correlate with LVH, night HBPM correlated well with LVH. The previously held view that "management of hypertension exclusively based on self-measurement of BP at home cannot be recommended"⁽¹³⁾ may need to be reviewed if HBPM is to be used to record BP at night.

HBPM has been shown to have reproducible readings, with a standard deviation < 3.1 mmHg for both systolic and diastolic measurements. Thus, the results of electronic devices are also reproducible, with the difference between models found to be less than that resulting from human variations in the auscultation of BP.⁽¹⁴⁾ However, these observations applied only to self-measurement of BP during the daytime. Recently, it has been observed that there was a significant variability in night-time home BP recordings due to the variable quality of sleep.⁽⁴⁾ In addition, another practical problem would be the training of bystanders to record BP in the middle of the night. Hence, the observations of our study, which involved a small group of subjects, have to be confirmed in a larger sample size. The findings of the study have important implications in the management of hypertension at the primary care level. In addition to the known benefits of involving the patients in the management of their hypertension, detecting white coat hypertension and masked hypertension,⁽¹⁵⁾ this study extended the role of HBPM in the initial evaluation of hypertension due to the good correlation between night-time home BP recording and LVH. Since the technique of recording BP using HBPM is simple, reliable and more convenient compared to 24-hour ABPM (which was the only method for documenting nocturnal dip in BP until now), there may be wider acceptance of this method among hypertensive individuals, although HBPM may not replace other sensitive techniques for detecting LVH.

In conclusion, systolic BP recorded at night using the HBPM method has good correlation with LVMI. Hence, recording nocturnal BP using an electronic BP apparatus could identify dippers/non-dippers and help to predict LVH. HBPM is thus a reliable and cost-effective method that could be useful in a resource-limited setting.

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