ORIGINAL ARTICLE

Value of Ambulatory Blood Pressure Monitoring in Evaluation of Blood Pressure Control in Patients on Antihypertensive Treatment

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ABSTRACT

Background: The conventional method of single, office measurement of blood pressure (BP) may not be accurate for assessing the adequacy of BP control, which is vital to reduce morbidity and mortality associated with hypertension. Ambulatory blood pressure (ABP) monitoring, by allowing prolonged BP monitoring, may provide incremental information for this purpose.

Methods: In this retrospective study, ABP monitoring records of 158 consecutive hypertensive subjects on antihypertensive treatment were analyzed and correlated with office BP recordings.

Results: The mean age of the subjects was 50.5 ± 16.1 years and 74.7% were males. Of the 158 subjects, 62 (39.2%) had "controlled office BP" (BP <140/90 mmHg) and the remaining 96 (60.8%) had "uncontrolled office BP" (BP > 140/90 mmHg). Overall, ABP monitoring was performed for an average of 25.7 ± 7.3 h, which included 15.7 ± 4.5 h of day-time recording and 9.9 ± 3.1 h of night-time recording. As compared to the patients with uncontrolled office BP, those with controlled office BP had lower 24-h BP, day-time BP, night-time BP, and the overall BP load. However, despite apparently controlled office BP, a significant proportion of these patients (24.2%) had increased 24-h average ABP and 58.1% patients had at least 40% day-time BP values above the normal range. Similarly, 10.4% patients with uncontrolled office BP actually had normal 24-h average BP and normal BP load (<40% day-time BP values above the normal range). In addition, patients with controlled office BP had less marked nocturnal fall in BP with nearly half of the subjects showing inadequate fall or even paradoxical increase in diastolic BP during night-time as compared to only 26% of those with uncontrolled office BP (p value= 0.014).

Conclusions: Although, compared to the patients with uncontrolled office BP, those with controlled office BP had lower BP readings on ABP monitoring, a substantial proportion of them still had uncontrolled 24-h BP and elevated overall BP load. In addition, the physiological, nocturnal drop in BP was blunted or even reversed in these patients. The ABP monitoring could potentially alter treatment in almost one-fourth of all patients. (J Clin Prev Cardiol 2012;1(3):101-7)

Key Words: BP load; dipper; nondipper.

Introduction

Hypertension is currently one of the leading killers worldwide. As per the World Health Organization estimates, suboptimal blood pressure (BP) is the most common attributable risk factor for death throughout the world. It is responsible for 62% of all cerebrovascular disease and 49% of all ischemic heart disease worldwide (1). Every 20 mmHg increase in systolic blood pressure (SBP) and every 10 mmHg increase in diastolic blood pressure (DBP) increases mortality from both ischemic heart disease and stroke by twofold (2). Consequently, effective control of BP remains the single-most effective therapeutic strategy to prevent cardiovascular morbidity and mortality. It is estimated that a 5 mmHg reduction in SBP in the population is likely to result in a 14% overall reduction in mortality due to stroke, a 9% reduction in mortality due to ischemic heart disease, and a 7% decrease in all-cause mortality (3,4).

Conventionally, diagnosis and management of hypertension are based on office-based recordings of BP. However, it is increasingly recognized that a single office measurement of BP may not accurately reflect a patient's actual BP burden. Studies using prolonged ambulatory BP (ABP) monitoring have revealed significant differences between the office BP measurements and the 24-h average BP measured by ambulatory recordings (5–7). Thus, the antihypertensive treatment based on office BP measurement alone may

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be misleading and inappropriate and ABP monitoring may prove to be useful in overcoming these limitations (6,8,9). However, as there is no data to document value of ABP monitoring in guiding antihypertensive therapy in Indian patients, we sought this study to derive information about potential utility of ABP monitoring in our patients receiving treatment for hypertension.

Methods

One hundred and fifty eight consecutive hypertensive subjects, who were on pharmacological treatment for hypertension and who had undergone ABP monitoring, were included in this retrospective study. The ABP monitoring was performed for clinical indications, as advised by their treating physicians. The monitoring was performed using the commercially available devices (Tonoport V, GE Medical Systems) for this purpose which employed oscillometric method for measuring BP. The typical recording duration was 24 h, with measurements repeated every 30 min during the day-time and every 60 min during the night-time.

The patients' age, gender, office BP recordings and findings on ABP monitoring were retrieved from the ABP monitoring lab records. The patients were divided in two groups, based on their office BP recordings. If the office BP values were <140/90 mmHg, the patients were considered to have "controlled office BP," whereas those with higher values were labeled as having "uncontrolled office BP."

On ABP monitoring, the average SBP and DBP over the entire monitoring period, during the day-time and during the night-time were recorded. The ABP was considered abnormal if the average values were >140/90 mmHg during the day-time or >135/85 mmHg over the entire monitoring period or >125/75 mmHg during the night-time (10). The percentage of BP recordings above these cut-off values were also noted. Day-time BP load was considered to be increased if at least 40% of all day-time SBP or DBP values were above the cut-off limits (11). In addition, the nocturnal drop in SBP and DBP was also recorded. A nocturnal drop of at least 10% from day-time average SBP or DBP was considered to be normal and such patients were labeled as "dippers" (10). Those who had less marked fall in BP were labeled as nondippers, whereas those with paradoxical rise, instead of normal fall in BP during night-time, were labeled as inverse-dippers.

Statistical Analysis

The data was managed on Microsoft excel spreadsheet (version 2007, Microsoft Corp, Seattle, WA). Values were expressed as mean (± standard deviation) or as percentages. Comparisons between the groups were done using Student's unpaired t-test or chi-square test wherever appropriate. A p value <0.05 was considered statistically significant. Statistical analysis was performed using SPSS for Windows (release 15.0, SPSS Inc).

Results

The mean age of the subjects was 50.5 ± 16.1 years and 74.7% of them were males. Overall, the mean office SBP and DBP were 140.9 ± 18.6 mmHg and 89.1 ± 13.4 mmHg, respectively. Of the 158 subjects, 62 (39.2%) had "controlled office BP" (office BP <140/90 mmHg) and the remaining 96 patients had "uncontrolled office BP" (office BP > 140 mmHg systolic and/or > 90 mmHg diastolic). There was no difference between the two groups with respect to age and gender (Table 1).

Table 1.
Clinical characteristics of the patients with controlled and uncontrolled office blood pressure readings

Parameter	Controlled office BP (n=62)	Uncontrolled office BP (n=96)	P value
Age (years)	49.3 ± 16.0	51.3 ± 16.2	0.45
Male gender	47 (75.8%)	71 (74%)	0.85
Office BP – systolic (mmHg)	125.5 ± 9.2	150.9 ± 16.3	<0.001
Office BP – diastolic (mmHg)	78.2 ± 8.5	96.2 ± 11.0	<0.001

The values are mean ± standard deviation or actual numbers with percentages in parentheses. BP, blood pressure.

ABP Monitoring

Overall, the ABP monitoring was performed for an average of 25.7 ± 7.3 h, which included 15.7 ± 4.5 h of day-time recordings and 9.9± 3.1 h of night-time recordings.

Average BP values and BP load (Table 2, Figures 1 and 2)

As compared to the patients with uncontrolled office BP, those with controlled office BP had lower average 24-h ABP (SBP 125.8 ± 9.8 vs. 140.6 ± 13.3 mmHg, DBP

78.5 ± 8.0 vs. 87.1 ± 9.7 mmHg, p value <0.001 for both), day-time ABP (SBP 128.1 ± 9.0 vs. 144.2 ± 13.2 mmHg, DBP 81.0 ± 8.6 vs. 90.7 ± 9.9 mmHg, p value <0.001 for both) and night-time ABP (SBP 120.1 ± 14.0 vs. 130.7 ± 16.0 mmHg, p value <0.001; DBP 72.3 ± 9.9 vs. 77.2 ± 10.8 mmHg, p value 0.005). Overall, 24.2% patients with controlled office BP had average ABP in the abnormal range as compared to 72.9% patients with uncontrolled office BP (p <0.001) (Table 2, Fig. 1).

Of the 62 patients with controlled office BP, 26 (41.9%) had at least 40% of the day-time BP values above the normal range and thus had increased day-time BP load. In contrast, nearly 90% of the patients with uncontrolled office BP had increased day-time BP load (p <0.001) (Fig. 2).

Nocturnal fall in BP (Table 2, Figures 3)

The patients with controlled office BP had less marked drop in BP during night-time as compared to the patients with uncontrolled office BP (SBP 10.5 ± 10.7% vs. 14.4 ± 9.0%, p value 0.013; DBP 6.3 ± 7.8% vs. 9.3 ± 7.0%, p value 0.014). More than half of the patients in both

Table 2.
The findings on ambulatory blood pressure monitoring in patients with controlled and uncontrolled office blood pressure readings

Parameter	Controlled office BP (n=62)	Uncontrolled office BP (n=96)	P value
24-hour average BP			
Systolic BP (mmHg)	125.8 ± 9.8	140.6 ± 13.3	<0.001
Diastolic BP (mmHg)	78.5 ± 8.0	87.1 ± 9.7	<0.001
Abnormal systolic BP*	10 (16.1%)	59 (61.5%)	<0.001
Abnormal diastolic BP*	13 (21.0%)	51 (53.1%)	<0.001
Overall abnormal BP*	15 (24.2%)	70 (72.9%)	<0.001
Day-time average BP			
Systolic BP (mmHg)	128.1 ± 9.0	144.2 ± 13.2	<0.001
Diastolic BP (mmHg)	81.0 ± 8.6	90.7 ± 9.9	<0.001
Abnormal systolic BP#	7 (11.3%)	57 (59.4%)	<0.001
Abnormal diastolic BP#	9 (14.5%)	46 (47.9%)	<0.001
Overall abnormal BP#	11 (17.7%)	68 (70.8%)	<0.001
Night-time average BP			
Systolic BP (mmHg)	120.1 ± 14.0	130.7 ± 16.0	<0.001
Diastolic BP (mmHg)	72.3 ± 9.9	77.2 ± 10.8	0.005
Abnormal systolic BP$^{\Psi}$	21 (33.9%)	58 (60.4%)	0.001
Abnormal diastolic BP$^{\Psi}$	23 (37.1%)	56 (58.3%)	0.007
Overall abnormal BP$^{\Psi}$	29 (46.8%)	73 (76.0%)	<0.001
Day-night difference in BP			
Systolic BP (%)	-6.3 ± 7.8	-9.3 ± 7.0	0.013
Diastolic BP (%)	-10.5 ± 10.7	-14.4 ± 9.0	0.014

The values are mean ± standard deviation or actual numbers with percentages in parentheses.
*Cut-off values for abnormal 24-h average blood pressure >135/85 mmHg, #abnormal day-time blood pressure >140/90 mmHg and $^{\Psi}$abnormal night-time blood pressure >125/75 mmHg.
BP, blood pressure.

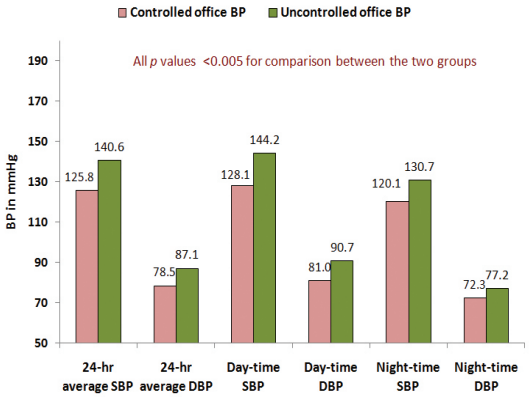

Figure 1. Ambulatory blood pressure recordings in patients with controlled and uncontrolled office blood pressure readings. BP, blood pressure; DBP, diastolic blood pressure; SBP, systolic blood pressure.

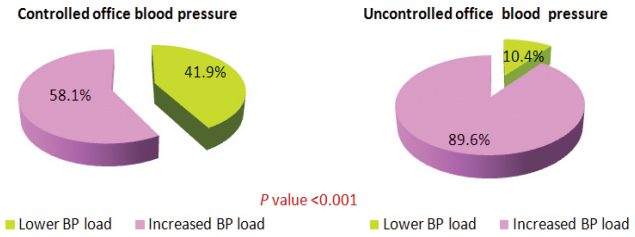

Figure 2. Proportion of patients with increased day-time blood pressure load (defined as >40% day-time blood pressure values above the cut-off). BP, blood pressure.

the groups (54.8% of those with controlled office BP and 52.1% with uncontrolled office BP, *p* - NS) were classified as nondippers based on SBP reduction during the night-time. The fall in DBP was much greater with only less than one-third of the patients being nondippers. However, more patients with controlled office BP (32.3%) were nondippers as compared to those with uncontrolled office BP (18.8%, *p* value = 0.014). In addition, a significant proportion of patients had paradoxical night-time rise in SBP or DBP, which again was more common in patients with controlled office BP (21.0% vs. 10.4% with, *p* = 0.066).

Discussion

In the present study, we investigated the role of ABP monitoring in assessing the adequacy of BP control in hypertensive subjects receiving antihypertensive treatment. The study showed that almost a quarter of all patients with controlled office BP had elevated average BP on 24-h ABP monitoring. Similarly, a quarter of those with uncontrolled office BP had normal average BP on ABP monitoring. Thus, ABP monitoring could potentially alter treatment in almost 25% of all patients. In addition, a significant proportion of the patients in both the groups did not have adequate drop in blood pressure during night-time – a finding which was paradoxically more common in patients with controlled office BP.

It is well known that BP is controlled by a number of neurohormonal factors, which are responsible for the significant temporal variability seen in BP during normal life as well as in disease states. Accordingly, a single BP reading, as obtained in a physician's office, is unlikely to reflect the overall status of BP burden in a given individual (6,7). In contrast, ABP monitoring allows prolonged BP monitoring in a setting which is

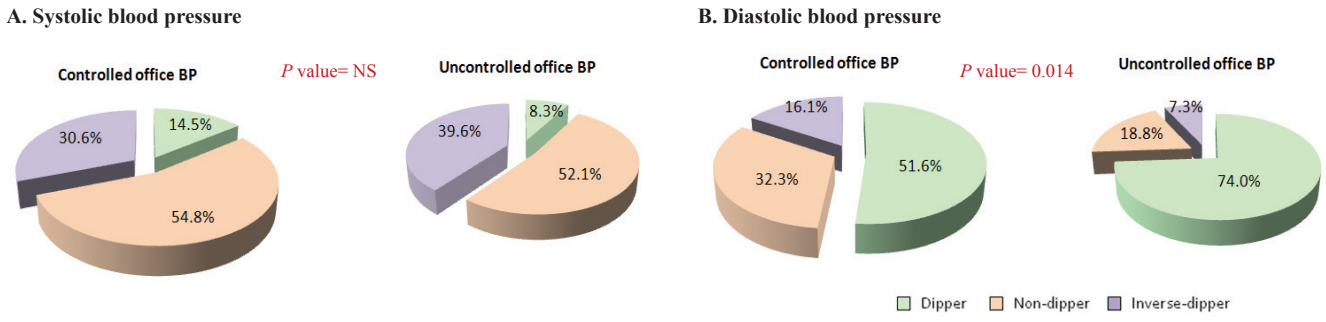

Figure 3. Proportion of patients with normal nocturnal fall, inadequate fall or paradoxical rise in systolic blood pressure (A) and diastolic blood pressure (B).
BP, blood pressure.

very close to the patients' daily life and is therefore believed to provide more accurate estimates of true BP status and the resultant vascular injury. Indeed, a number of studies have shown that compared to the office BP, ABP predicts cardiovascular risk better and has much stronger correlation with hypertension-related organ damage (12–19). Furthermore, ABP has been shown to provide more accurate estimates of BP reduction with antihypertensive therapy and is more accurate in tracking improvements in end-organ structure and function achieved with effective BP control (19–23). Given these advantages, ABP monitoring has been recommended as a routine modality for diagnosis of hypertension as well as for monitoring response to antihypertensive treatment (9).

Numerous studies have demonstrated the utility of ABP monitoring in guiding antihypertensive management in clinical practice and in comparing BP-lowering efficacy of different pharmacological agents (8,20,23–25). In a study comparing placebo and an alpha-adrenergic blocker terazosin, Drayer et al. showed that ABP was more sensitive in detecting changes in BP with tearzosin than office BP measurements (23). In a randomized, controlled study involving 419 patients, Staessen et al. showed that treatment guided by ABP monitoring resulted in much lower requirement of antihypertensive drugs without adversely affecting BP control, general well-being and end-organ damage (20). In our study, we found that almost a quarter of the patients with controlled office BP actually had increased 24-h average BP on ABP monitoring and were therefore candidates for more intensive treatment. At the same time, more than a quarter of all the patients with uncontrolled office BP had normal 24-h average BP. After excluding from these the 16.7% patients who had increased day-time BP load, almost 10% patients still remained who had reasonably well-controlled BP and therefore did not require any further intensification of antihypertensive therapy. Thus, ABP monitoring in our study could alter treatment in almost a quarter of all the patients, with significant implications. On one hand, it could protect patients from the potential ill-effects of inadequate BP control and on the other hand, it could save patients from the harmful side-effects and the cost of the unnecessary additional treatment.

An added advantage of ABP monitoring is its ability to allow assessment of diurnal variations of BP which have important prognostic implications. In normotensive subjects, BP has a distinct circadian pattern. It tends to increase during day-time, peaks during the day and then falls to a nadir at midnight, before rising again early in the morning. Both, a lack of adequate drop in BP during night-time and an exaggerated early morning surge are associated with adverse outcomes (26–29). Night-time BP, in particular, has been shown to be an important determinant of outcomes in patients with hypertension. There is evidence to suggest that the night-time BP may even be superior to day-time BP in prediction of cardiovascular risk (15–18). In addition, subjects in whom nocturnal decrease in BP is blunted (nondippers) or those who have paradoxical rise in BP have been reported to have a greater prevalence of organ damage and a greater risk of adverse cardiovascular events (26–28,30,31). In a recent study involving 30 Indian subjects, Pai et al. found that night BP measurements were significantly lower in subjects without left ventricular hypertrophy and had statistically significant correlation with the left ventricular mass index (31). In our study, we found that a significant proportion of patients did not have adequate drop in BP or actually had paradoxical rise in BP during night-time which would indicate increased long-term cardiovascular risk in these subjects. However, it can be argued that the antihypertensive therapy itself could have blunted nocturnal drop in BP as evidenced by lower day–night difference in BP in patients with controlled office BP as compared to those with uncontrolled office BP. Nonetheless, paradoxical rise in night-time BP, which was seen in as many as 15% of all subjects, was clearly an abnormal finding and could not have resulted from the antihypertensive treatment.

Limitations

The study had some important limitations that need to be considered. Due to its retrospective nature, we could not obtain detailed information about the baseline clinical and biochemical parameters of the patients and hence could not determine their influence on BP control. However, the lack of this data did not affect the primary purpose of the study which was to observe the differences between the office measurements of BP and the ABP monitoring. Similarly, we could not ascertain the effect of different antihypertensive agents on BP control, particularly the magnitude and duration of BP reduction with different agents. However, as mentioned above, this too did not compromise the primary aim of the study.

Conclusions

Although, compared to the patients with uncontrolled office BP, those with controlled office BP had lower BP readings on ABP monitoring, a substantial proportion of them still had uncontrolled 24-h average BP and increased overall BP load. At the same time, many of the patients with uncontrolled office BP had normal average BP on ABP monitoring. Thus, ABP monitoring could potentially alter treatment in almost 25% of all patients. In addition, ABP monitoring also disclosed blunted or even reversed nocturnal drop in BP in a significant number of these patients. The significance of these findings in day-to-day management of hypertension needs to be assessed in large, prospective studies.

Conflict of Interest

None

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