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Original Article

Role of ambulatory blood pressure monitoring in hypertensive patients having controlled office blood pressure

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ABSTRACT

Background and objectives: Ambulatory blood pressure (BP) monitoring has become useful in the diagnosis and management of hypertensive individuals. In this study we tried to know the role of office and ambulatory BP in treated hypertensive patients.
Methods and patients: Prospective cohort of 561 treated hypertensive patients were enrolled in the study. Hypertension definitions were according to JNC 8 classification. Office BP and ambulatory BP monitoring was done according to defined protocol.
Results: From a subgroup of 158 treated hypertensive patients, 91(16.2%) patients were having white coat hypertension (p value 0.00 by Pearson chi square test). In a subset of 403 patients who were having controlled BP on the day of enrolment as well as on the day of attaching ambulatory BP monitor; 98 (17.4%) patients were having masked uncontrolled hypertension (MUCH). In addition there was very significant percentage of non-dippers and reverse dippers. In our study we found that office BP has a moderate to low specificity and sensitivity and low negative predictive value for overall control in treated hypertensive patients.
Conclusion: Ambulatory BP monitoring should be included in the management protocol of treated hypertensive patients, for the optimal BP control.

1. Introduction

The importance of Ambulatory blood pressure monitoring (ABPM) in managing hypertension has been acknowledged and a number of authoritative bodies have now issued guidelines on the use of ABPM[1–5] (Tables 1 and 2).

Several studies have shown that in hypertensive patients, left ventricular hypertrophy; and other markers of organ damage correlate with ambulatory BP more closely than with office BP.[6,7] Furthermore, 24-h average BP has been consistently shown to have a stronger relationship with morbid or fatal events than office BP.[8–11] Evidence from meta-analyses of published observational studies and pooled individual data, however, has shown that ambulatory BP in general is a more sensitive risk predictor of clinical CV outcomes, such as coronary morbid or fatal events and stroke than office BP.[12–14]

Once antihypertensive treatment is initiated, the main aim is always to achieve a BP goal as recommended by the guidelines which is usually confirmed by single office BP reading. If patient has a BP reading which fits in the goal according to his age and co morbidity status, it is presumed that 24 h BP is under control but without any conclusive evidence. Keeping in view the large burden of hypertension in our part of world; monitoring of treated hypertensives becomes important to prevent the cardiovascular mortality and morbidity. Therefore, we felt the need to test the available tools so that our patients are benefitted to the maximum. We conducted this study to know the value of office BP and ABPM in treated hypertensive patients.

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Table 1
Descriptive statistics of various variables and Pearson correlation with 2 tailed significance.

VARIABLE	MEAN	SD	P value
AGE	46.98	14.27	
SYSTOLIC OFFICE BP	117.6	32.5	
DIASTOLIC OFFICE BP	79.51	26.24	
SYSTOLIC ACTIVE BP	125.77	21.41	0.014
DIASTOLIC ACTIVE BP	78.85	14.731	0.000
SYSTOLIC 24 HOUR BP	122.58	16.84	0.000
DIASTOLIC 24 HOUR BP	75.34	11.735	0.000
MINIMUM SYSTOLIC BP	75.14	38.82	0.018
MINIMUM DIASTOLIC BP	41.25	22.92	0.036
HBI (Hyperbaric Impact)	93.66	148.66	0.000*
DIURNAL INDEX	8.4	7.79	0.000*
MORNING SURGE	10.67	13.43	0.000*
MAP(Mean Arterial Pressure)	90.01	15.13	0.005*
PTE(Percent Time Elevation)	26.19	26.73	0.020*
PULSE	75	12.22	0.917*
PULSE PRESSURE	39.32	21.27	0.11*
DOUBLE PRODUCT	7647.87	4029.733	0.022*
SYSTOLIC PASSIVE	110.9	23.9	0.083
DIASTOLIC PASSIVE	65.92	15.16	0.000

Hypertensive Time Index, or percent time elevation (**PTE**) is the proportion of time during which blood pressure values are higher than considered to be normal. The hypertension time index compares the period with elevated blood pressure to total time. **Hyperbaric impact (HBI)** or hypertension load provides information on how long blood pressure is higher than normal and how much it is higher than the upper limit of normal ambulatory blood pressure during ABPM monitoring**. Morning surge** is basically a normal rise from a lower night blood pressure level to a somewhat higher day blood pressure level.

Table 2
Pharmacotherapy charecteristics in patients with treated hypertension (N = 561).

VARIABLE*	FREQUENCY
ACE INHIBITORS	32(5.7%)
CALCIUM CHANNEL BLOCKERS	72(12.8%)
ACE INHIBITORS + CCBS	3(0.53%)
BETA BLOCKES	21(3.74%)
BETA BLOCKERS + ACE INHIBITORS	32(5.7%)
ARBS	58(10.3%)
ARBS + CALCIUM CHANNEL BLOCKERS	42(7.4%)
DIURETICS	28(4.9%)
DIURETICS + CALCIUM CHANNEL BLOCKERS	33(5.8%)
DIURETICS + CALCIUM CHANNEL BLOCKERS + ARBS	56(9.9%)
BETA BLOCKERS + ARBS	49(8.7%)
DIURETICS + ARBS	90((16%)
ALFA BLOCKERS	11(1.9%)
MORE THAN 3 DRUGS	34(6.06%)

2. Methods

A Prospective cohort of 602 treated hypertensive patients with controlled office blood pressure as per JNC 8 hypertension guidelines was enrolled after written informed consent. Since, 41 of enrolled patients had sub-optimal readings, therefore they were excluded; and only 561 were eligible for the study.

2.1. Inclusion criteria

Hypertensive patients on pharmacologic treatment having at least one reading of accepted office blood pressure (BP) goal as defined in the JNC 8 hypertension guidelines.[15]

2.2. Exclusion criteria

- Patients of hypertension less than 18 years of age.
- Hypertensive patients not on medical management.
- First time detected hypertension.
- Uncontrolled hypertension.
- Normotensive patients.

Baseline ECG was done in all patients and patients having atrial fibrillation were excluded as it has been shown to result in inaccuracies while recording blood pressure.[16]

2.3 Office Blood Pressure (office BP) Measurement: The office BP was measured according to accepted practices.[17]

2.3. Ambulatory blood pressure monitoring (ABPM)

ABPM was performed with a portable BP measuring device (Meditech ABPM-05), usually on the nondominant arm, for a 24 h period. At the time of fitting of the portable device, care was taken that the difference between the initial values and those from BP measurement by the operator was not greater than 5 mmHg. In the event of a larger difference, the ABPM cuff was removed and fitted again. The patient was instructed to engage in normal activities but to refrain from strenuous exercise at the time of cuff inflation; and to stop moving and talking and keep the arm still with the cuff at heart level. The patient was asked to provide information in a diary on symptoms and events that may influence BP, in addition to the times of drug ingestion, meals and going to and rising from bed.

Measurements were made at 15min intervals during the day and every 30 min overnight. Excessive intervals between BP readings were avoided because they reduce the accuracy of 24-h BP estimates.[18] The measurements were downloaded to a computer and a range of analyses was performed. At least 70% of BPs during daytime and night-time periods had to be satisfactory, or else the monitoring was repeated.

Since this study was undertaken 4 years back, the BP goals were set as per JNC 8 guidelines, although, new guidelines suggest different goals for various subsets (ACC A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines).[19]

The nature of the antihypertensive taken by the patients was noted by the investigator.

2.3.1. Definitions

- **Dipping** is defined as the difference between the mean systolic pressure in the day and mean systolic pressure during the night, expressed as a percentage of day time mean with the accepted normal between 10% and 20%.[20]

White Coat Hypertension is defined as office systolic/diastolic blood pressure readings of ≥140/90 mm Hg and a 24-h blood pressure <130/80 mm Hg, defined as high BP in office setting with normal BP at home.[21]

Masked Uncontrolled Hypertension MUCH is used to describe treated patients in whom BP levels are sub-optimally controlled according to ABPM, but who are considered controlled according to clinic BP targets by current treatment guidelines recommendations (<140/90 mmHg).[22]

Statistical analysis was done using the SPSS software. Descriptive statistics was done with students t test; Pearson correlation was used to see the correlation between various parameters as continuous variables, Pearson chi square test was used for categorical variables, all p values were two tailed and were taken significant when less than 0.05.

3. RESULTS and DISCUSSION

561 patients were eligible for the study, 333(59%) of them were male and 228(41%) were female. Mean age of our patients was 46.98 years.

By Pearson correlation (Bivariate analysis) we found a weak correlation {all values of r (coefficient of correlation) were less than 0.3} between various ABPM parameters and Office BP. From this observation we inferred that Office BP can poorly predict the circadian changes in BP in treated hypertensive patients.

3.1. White coat hypertension (white coat effect)

Since single office BP reading within normal range was sufficient to enrol the patient, after enrolling of the patients some of them had higher BP on the day of attachment of ambulatory BP monitor but they were included in the study to see their actual control. From the total cohort of 561 treated hypertensives 158(28.1%). patients were having higher BP on the day of attaching the ambulatory BP monitor although they had BP with in normal range on the day of enrolment. Out of them 91(16.3%) of the patients were having white coat effect. As categorical variable univariate analysis of office BP and 24 h BP was done with a p value 0.000(Pearson chi square test). From these observations we inferred that a significant number of patients presumed to be having hypertension on the day of attachment of BP monitor were actually having white coat effect or white coat hypertension. . Previous studies have reported that 36% of their patients were having White Coat Effect[23,24]

3.2. Masked uncontrolled hypertension (MUCH)

In the subset of 403 treated hypertensive patients based on 24-hr ABPM criteria, 98 (24.3%) patients were found to have MUCH, of them 35(35.71%) were women and 63 were (64.29%) men. Furthermore, 36(36.73%) patients belonged to 18–39 year age group, 40(40.82%) patients were from 40 to 59 year age group and 22(22.45%) patients were more than >60 years of age. After treating office BP and 24 h average BP as categorical variables, on univariate analysis, a significant number of patients with hypertension who were presumed to be having a good control were actually having masked uncontrolled hypertension(Pearson chi square test; a two sided p value = 0.00).

There was a male predominance in patients having MUCH; middle age group patients were more likely having MUCH as compared to other age groups.

From the studies done on the prevalence of MUCH in treated hypertensive patients, one of the study reported it to be 31.1% (4608/2778) according to 24-hr ABPM criteria.[25,26] In our study we observed that the percentage of MUCH was higher in younger age groups, which may be one of the reasons of higher cardiovascular events in younger age groups in this part of the world.

3.3. Diurnal variations

In the cohort of 561 treated hypertensive patients (based on 24-hr ABPM criteria, 284 (51%) patients were non-dippers, of them 110(38.7%) were female and 174(61.3%) were male; 197 (35%) were normal dippers, of them 83(42.1%) were female and 114(57.9%) were male; 48(8%) were extreme dippers, of them 19(39.6%) were female and 29(60.4%) were male. Out of 32(6%) reverse dippers, 16(50%) patients were male and 16(50%) were female. Out of 284(51%) non-dippers, 120(42.3%) belonged to (18–39) age group, 107(37.7%) belonged to 40–59 year age group; and 57(20.1%) belonged to a group comprising of patients who were more 60 year old.

A subgroup of 197(35%) patients had normal dipping status, of them 54(27.4%) patients belonged to 18–39 year age group, 107(54.3%) patients belonged to 40–59 year age group and 36(18.3%) patients belonged to a group comprising of patients who were more than 60 years old. Out of 48(8%) extreme dippers, 11(22.9%) patients belonged to 18–39 year age group, 25(52.1%) patients belonged to 40–59 year age group and 12(25%) patients were more than 60 years old. A subgroup of 32(6%) patients were non dippers, of them 5(15.6%) patients belonged to 18–39 year age group, 14(43.3%) patients belonged to 40–59 year age group and 13 (40.6%) patients belonged to more than 60 year age group.

From above results we observed that there was a male predominance in non-dippers as well as reverse dippers. The younger age group patients were most commonly having non dipping pattern of nocturnal BP, this finding of ours needs a confirmation in larger cohort, since most of the patients (78%) were less than 60 years of age.

In one of the study, where investigators studied the clinical significance of dippers in hypertensives[27] the distribution of patterns was as follows: dipper (476, 42.3%), non-dipper (448, 39.8%), reverse dipper (140, 12.4%) and extreme dipper (62, 5.6%).

3.4. Measuring the diagnostic power of office BP with ABPM as standard

In the cohort of 561 treated hypertensive patients using ABPM as the gold standard the sensitivity of systolic office BP measurement for the diagnosis of hypertension was found to be 76.94%(confidence interval 72.56, 80.81), specificity 40.74%(confidence interval, 33.47, 48.44) positive predictive value 76.18% (confidence interval, 71.78, 80.08) and negative predictive value came out to be 41.77%(confidence interval, 34.37, 49.57) against 24 h systolic BP. Similarly sensitivity, specificity, positive predictive value and negative predictive value were 77.63(confidence interval, 73.12,81.57), 63.16%(confidence interval, 56.1,69.69) 85.45%(confidence interval, 76.02,84.22); and 59.11% (52.24,65.65)respectively, against 24 h diastolic BP.

There are no studies where the diagnostic power of office BP has been studied in treated hypertensive patients with ABPM as standard. In our study we observed that the negative predictive value of office BP measurement is very low in comparison to ambulatory BP monitoring, which implies that a normal office BP reading cannot rule out poor control in treated hypertensive patients. The latter finding of ours suggests the importance of ambulatory BP monitoring for the effective and optimal care of treated hypertensive patients.

What is already known? A significant proportion of patients of treated hypertension have white coat effect or masked uncontrolled hypertension.

What this study adds? Office BP has very poor correlation with 24 h ABPM, and it has a very low negative predictive value to rule out poor control in treated hypertensive patients.

4. Conclusion

Our study reveals that ABPM can be an indispensable investigation in hypertensive patients to guide the optimization of the anti-hypertensive treatment. A single office BP reading cannot tell anything about the overall control of hypertension. Office BP has very low negative predictive value to rule out hypertension in treated hypertensive patients. We conclude from our study that ambulatory BP monitoring should be a routine to optimize the treatment in treated hypertensive patients.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. ESH/ESC guidelines for the management of hypertension. *Eur Heart J*. 2013. https://doi.org/10.3109/08037051.2013.812549, 10.1093/eurheartj/eht151 and in Blood Pressure.
2. Joint National Committee on Detection. Evaluation and treatment of hypertension. The sixth report of the joint national committee. *Arch Intern Med*. 1997;157:2413–2446.
3. Guidelines Subcommittee. World health organization–international society of hypertension guidelines for the management of hypertension. *J Hypertens*. 1999;17:151–183.
4. Pickering T, for the American Society of Hypertension Ad-hoc Panel. Recommendations for the use of home (self) and ambulatory blood pressure monitoring. *Am J Hypertens*. 1996;9:1–11.
5. Myers MG, Haynes RB, Rabkin SW. Canadian Hypertension Society guidelines for ambulatory blood pressure monitoring. *Am J Hypertens*. 1999;12:1149–1157.
6. Gaborieau V, Delarche N, Gosse P. Ambulatory blood pressure monitoring vs. self-measurement of blood pressure at home: correlation with target organ damage. *J Hypertens*. 2008;26:1919–1927.
7. Bliziotis IA, Destounis A, Stergiou GS. Homevs. Ambulatory and office blood pressure in predicting target organ damage in hypertension: a systematic review and meta-analysis. *J Hypertens*. 2012;30:1289–1299.
8. Staessen JA, Thijs L, Fagard R, et al. Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. *JAMA*. 1999;282:539–546.
9. Clement DL, De Buyzere ML, De Bacquer DA, et al. Office vs. Ambulatory Pressure Study Investigators. Prognostic value of ambulatory blood-pressure recordings in patients with treated hypertension. *N Engl J Med*. 2003;348:2407–2415.
10. Dolan E, Stanton A, Thijs L, et al. Superiority of ambulatory over clinic blood pressure measurement in predicting mortality: the Dublin outcome study. *Hypertension*. 2005;46:156–161.
11. Sega R, Facchetti R, Bombelli M, et al. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: follow up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. *Circulation*. 2005;111:1777–1783.
12. Conen D, Bamberg F. Noninvasive 24-h ambulatory blood pressure and cardiovascular disease: a systematic review and meta-analysis. *J Hypertens*. 2008;26:1290–1299.
13. Boggia J, Li Y, Thijs L, et al. Prognostic accuracy of day vs. night ambulatory blood pressure: a cohort study. *Lancet*. 2007;370:1219–1229.
14. Fagard RH, Celis H, Thijs L, et al. Daytime and night-time blood pressure as predictors of death and cause-specific cardiovascular events in hypertension. *Hypertension*. 2008;51:55–61.
15. Evidence-based guideline for the management of high blood pressure in adults report from the panel members appointed to the eighth joint national committee (JNC 8). *JAMA*. 2014;311(5):507–520. https://doi.org/10.1001/jama.2013.284427.
16. Hypertension 1983; 5:264–269. 70 Stergiou GS, Kollias A, Destounis A, Tzamouranis D. Automated blood pressure measurement in atrial fibrillation: a systematic review and meta-analysis. *J Hypertens*. 2012;30:2074–2082.
17. ESH/ESC guidelines for the management of hypertension. *Eur Heart J*. 2013. https://doi.org/10.3109/08037051.2013.812549, 10.1093/eurheartj/eht151 and in Blood Pressure.
18. Boggia J, Li Y, Thijs L, et al. For International Database on Ambulatory blood pressure monitoring in relation to Cardiovascular Outcomes (IDACO) investigators. Prognostic accuracy of day versus night ambulatory blood pressure: a cohort study. *Lancet*. 2007;370(9594):1219–1229 [PubMed].
19. ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary A Report of the American College of Cardiology/American Heart Association Task Force on ClinicalPracticeGuidelinesPaulK.-Whelton,https://doi.org/10.1161/HYP.0000000000000066Hypertension.2017;HYP.0000000000000066 originally published November 13, 2017.
20. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension*. 2003;42:1206–1252 [PubMed] [Google Scholar].
21. O'Brien E, Parati G, Stergiou G, et al. On behalf of the European society of hypertension working group on blood pressure monitoring.European society of hypertension position paper on ambulatory blood pressure monitoring. *J Hypertens*. 2013;31:1731–1767.
22. Myers MG, Reeves RA. White coat phenomenon in patients receiving antihypertensive therapy. *Am J Hypertens*. 1991;4(10 pt 1):844–849. a randomised controlled trial protocol MASked-unconTrolled hypERtension management based on office BP or on ambulatory blood pressure measurement (MASTER) Study: a randomised controlled trial protocolGianfranco Parati,Enrico Agabiti-Rosei, George L Bakris, Grzegorz Bilo, Giovanna Branzi, BMJ Open. 2018; 8(12):e021038.Published online 2018 Dec 19. doi: 10.1136/bmjopen-2017-021038.
23. Prevalence of white coat effect in treated hypertensive patients in the community Myers Martin G, Oh Paul I, Reeves Richard A, Campbell D. *Joyner Am. J. Hypertension*. 1 June 1995;8(Issue 6):591–597.
24. Myers Martin G, Oh Paul I, Reeves Richard A, Campbell D. *Joyner Am. J. Hypertension*. 1 June 1995;8(Issue 6):591–597.
25. High prevalence of masked uncontrolled hypertension in people with treated hypertension Jose R Banigas, Luis m. Ruilope, Alejandro da la sierra, Juan J. da la Cruz, Manuel Gorostidi, Nieves Martel, Juan Garcia-Puig,John Deanfield. *Bryan Williams European Heart J*. 7 December 2014;35(46):3304.
26. Blood pressure control in hypertensive patients, cardiovascular risk profile and the prevalence of masked uncontrolled hypertension (MUCH)nabil nasir, alen dzubur, azra durak. *Mehmed Kulic and Nura NaserMed-Arch*. 2016 Aug;70(4):274–279.
27. Clinical Significance of Dipper Pattern in Hypertensive Patients Saturnino Suarez Ortega, Jeronimo Artiles Vizcaino, Noel Lorenzo Villalba , Miriam Serrano Fuentes, Elena Oliva Damaso and Jose Carlos Rodriguez Perez Hospital Universitario de Gran Canaria Dr Negrin, Barranco de la Ballena, s/n, Las Palmas de Gran Canaria, Las Palmas, 35000 Spain Ortega et al. *Biol Med*. 2016;8:6.