IJPSR (2014), Vol. 5, Issue 12 (Review Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 11 March, 2014; received in revised form, 24 June, 2014; accepted, 11 August, 2014; published 01 December, 2014

AMBULATORY BLOOD PRESSURE MONITORING: A NON-INVASIVE GOLD STANDARD FOR HYPERTENSIVE THERAPY

P. Lakshmi Sirisha, G. Kishore Babu *, P. Srinivasa Babu and P. Koteswari

Department of pharmaceutics, Vignan Pharmacy College, Vadlamudi, A.P. India

Keywords:

Blood Pressure; ABPM; Dipping;Non dipping; White coat hypertension.

Correspondence to Author:

G. Kishore Babu
Associate professor,
Department of Pharmaceutics,
Vignan Pharmacy College,
Vadlamudi, Guntur, (A.P.) - 522002,
India
E-mail: kishorempharm@gmail.com

ABSTRACT: Blood pressure (BP) is one of the major prognostic indicators in cardiovascular patients and in patients with chronic kidney disease (CKD). Accurate measurement of BP is important to classify an individual to confirm BP related risk and to continue treatment. The limitations of conventional technique can be surpassed by ambulatory blood pressure monitoring (ABPM). ABPM strengthens its superiority towards clinical BP measurement in point of its high reproducibility, high cost-effectiveness, assessment of white coat hypertension, provides multiple BP measurements. This review highlights ABPM technique and covers a brief introduction about hypertension, measurement of BP by 24-hr ABPM, clinical indications in various areas, ABPM device and its application thereby concluding that ABPM technique is superior both in terms of care and cost over conventional technique for diagnosis and treatment of hypertension.

INTRODUCTION: High blood pressure (BP) is sometimes called a 'silent killer' as it often has no symptoms and damage to the body and can build up for many years. High BP can lead to health conditions such as heart attack and stroke if left untreated. Although the percentage of patients being treated for hypertension has increased, the percentage of those who demonstrate control of BP has been declined. It has been estimated that the prevalence of hypertension will increase over the next two decades [1]. Since the likelihood of hypertension increases with age, the overall prevalence of hypertension tends to increase as more people live longer.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.5(12).5073-87

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.5(12).5073-87

Other potential inevitable risk factors which includes increased intake of fat, calories, salt, and alcohol, increased smoking, reduced intake of fresh fruit and vegetables, and reduced physical activity are expected as reasons for further increases in the future prevalence of the continuous rise of hypertension [2]. It's therefore vital that we have a guidance regarding the potential for improvement in diagnosis and treatment of hypertension. As per national and international survey data from all over the world it is apparent that the management of hypertension is suboptimal [3].

Classification of Hypertension

The classification of hypertension is shown in **Figure 1**. High blood pressure usually has no obvious symptoms and many people have it without knowing. The symptoms may include headache (in the morning particularly at the back of the head), Vertigo, Tinnitus, Light-headedness, Altered vision etc. Treatment includes Diuretics (Thiazides, High ceiling, K^+ Sparing), Angiotensin-

converting enzyme inhibitors, Angiotensin (AT_1receptor) blockers, Calcium channel blockers, β Adrenergic blockers, β + α Adrenergic blockers, α Adrenergic blockers, Central sympatholytics, vasodilators etc. Clinical studies reveals that hypertensive patients have better tolerability profile of these drugs [4].

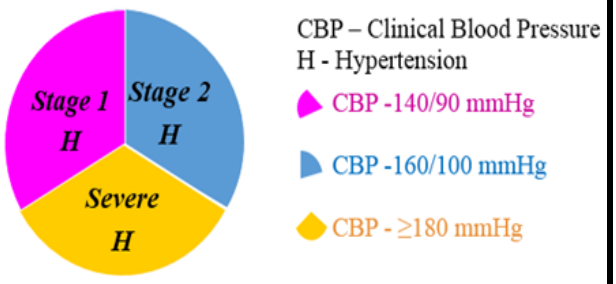


Figure 1: Classification of Hypertension

In hypertensive patients BP is required to reduce the cardiovascular diseases, particularly in patients with diabetes mellitus where reduction in BP is required. Clinical trials suggested that 75% of patients will require combination therapy to control blood pressure effectively. By the seventh report of Joint National Committee guidelines combination therapy is suggested as first line treatment for patients with >20mm Hg systolic and >10mmHg diastolic BP respectively [5]. Combination therapy increases the rate of BP control and requires less time to reach target BP with better tolerability than high dose therapy. It has fewer side effects, better patient compliance and low in cost [6, 7].

Ambulatory Blood Pressure Monitoring

Ambulatory blood pressure monitoring (ABPM) is a non-invasive method of obtaining blood pressure readings over twenty-four hours, whilst the patient is in their own environment, representing a true reflection of their BP. It is normally carried over 24 hours. This technique is now accepted as being indispensable to good clinical practice [8]. The National Institute for Health and Clinical Excellence (NICE) guideline recommends that a diagnosis of primary hypertension should be confirmed by using 24-hour ABPM. ABPM is gaining acceptance as a useful modality for the evaluation of BP levels in both hypertension research and in the clinical setting.

This statement summarizes the current research and clinical applications of ABPM in children and adolescents and offers recommendations on implementation of ABPM in practice and interpretation of results. The normal range for ABP (ambulatory Blood Pressure) has been established in 2 ways: first, by comparison of the ABP level that corresponds to a clinical pressure of 140/90 mm Hg and secondly, by relating ABP to risk in prospective studies. The suggested values for daytime, night time, and 24-hour average levels are shown in the following **Table 1**:

TABLE 1.SUGGESTED VALUES OF VARIOUS BLOOD PRESSURES IN NORMAL AND HYPERTENSIVE PATIENTS.

	Optimal	Normotension	Hypertension
24-h pressure (mmHg)	<125/75	<130/80	≥135/85
Daytime pressure (mmHg)	<130/80	<135/85	≥140/90
Night-time pressure(mmHg)	<115/65	<120/70	≥125/75

Advantages of ABPM

- Provides multiple blood pressure measurements
- Avoids potential for observer error and bias
- Measures blood pressure during usual activities of daily living and during sleep
- Can evaluate circadian variation of blood pressure
- More closely correlates to surrogate end points, such as left ventricular hypertrophy, than clinical blood pressure
- Can assess white-coat hypertension and white-coat or "alerting" responses
- Can be more reproducible than clinical blood pressure
- Highly essential for effective Hypertensive therapy

Limitations of ABPM

- Patient discomfort
- Cost of technology
- Disturbance of work and sleep
- Limited normative data
- Limited diagnostic, therapeutic and heart rate guidelines
- Reimbursement issues
- Loss of data due to technical problems

Prognostic Significance

Several prospective studies have documented that the risk of morbid events can be better predicted by the average level of ABP than by clinical blood pressure (CBP) [9, 10]. In addition to mean absolute levels of ABP, certain ABP patterns may also predict BP-related complications. Among these the patterns of greatest interest are white coat hypertension (WCH) and nondipping BP. WCH is a condition in which CBP is in the hypertensive range but ABP is normal or low.

Individuals with WCH are at lower risk for BP-related complications in comparison to those with sustained hypertension. Whether the risk of cardiovascular disease in WCH exceeds that of non-hypertensive subjects is an important but unresolved issue. Using both daytime and nocturnal ABP, one can identify individuals, termed nondippers, who do not experience the decline in BP that occurs during sleep hours.

Usually, night-time (asleep) BP drops by 10% or more from daytime (awake) BP. Individuals with a nondipping pattern appear to be at increased risk for BP-related complications compared with those with a normal dipping pattern [11, 12]. **Table 2** gives a brief comparison of clinical, ambulatory and home blood pressure monitoring. [13]

TABLE: 2 COMPARISON OF CLINICAL, AMBULATORY, AND SELF (HOME) BLOOD

	Clinical BP Monitoring	**ABPM**	**Self-BP Monitoring**
Predicts events	Yes	Yes	Yes
Diagnostic utility	Yes	Yes	Yes
Detects white coat , morning and masked hypertension	No	Yes	Yes(Limited)
Screening for hypertension	Yes	No	No
Evaluation of therapy	Yes	Yes (limited repeat uses)	Yes
Normal limit for averagerisk patients (mm Hg)	140/90	130/80 (24-hour) 135/85 (awake) 120/75 (sleep)	135/85
Presence/absence of nocturnal dipping	No	Yes	No
Short-term day and night BP/HR variability	No	Yes	No
Long-term BP variability (if repeated	Yes	Yes (Limited)	Yes
BP load	No	Yes	No
24-h heart rate; 24-h mean BP; 24-h pulse pressure; measures of variability; ambulatory arterial stiffness index; cusum plots; cardiovascular load; area under the curve	Not applicable	Not applicable	Can be computed from ABPM recordings
Duration of procedure	Brief depending on No. of measurements recorded	To equate with daytime ABPM, BP should be measured * 2, morning and evening, for 7 days, with first day discarded and 24 BPs averaged	Usually 24-h BP measurements at30-min intervals during day and night with minimal requirement of 14 daytime and 7 night-time Measurements
Medical requirements	Conventional technique in clinical environment under medical supervision	Should be used under medical supervision, but device often purchased and used without medical supervision	Must be used and interpreted under medical supervision
Cost	Low	High	Low
Reimbursement	Yes	Partial	No

PRESSURE MONITORING

Superiority of ABPM over CBPM in Primary Care and Cost

An individual's BP level has long been defined by physicians or nurses based on clinical BP recordings. However, clinical BP may not necessarily represent an individual's usual BP level. The limitations of CBPM arise from at least four sources [13]:

- The inherent variability of BP coupled with the small number of readings that are typically taken in the doctor's clinical,

- Poor technique (e.g., terminal digit preference, rapid cuff deflation, improper cuff, and bladder size),
- The white coat effect (increase of BP that occurs in the medical care environment), and
- The masked effect in the case of 'masked' hypertension.

Several studies suggest that clinical BP is higher than self-measured or ambulatory BP's [14-17]. Classification of a patient's hypertensive status by conventional measurement techniques may thus lead to over diagnosis and overtreatment of hypertension. One of the first studies of ABPM in primary care showed that BP measurements made by doctors were much higher than those using ABPM, leading the authors to conclude that it was time to stop using high BP readings documented by general practitioners to make treatment decisions[18-20]. BP control was underestimated in more than one third of patients and overestimated in some 5% by CBPM as compared to ABPM.

Notably, BP was uncontrolled by both methods of measurement in 43% of patients. High risk patients showed poorer ABPM control than low to moderate risk patients in spite of receiving much more antihypertensive treatment [21, 22]. There is increasing evidence that ABPM is a more accurate predictor of cardiovascular morbidity and mortality than CBPM [23, 24]. ABPM is also useful in the evaluation of drug resistance and medication compliance [25]. Recent studies obtained in compliance with American Heart Association guidelines indicate that ABPM data may more accurately reflect a patient's actual BP than casual or in-clinical BP measurements and may improve the physician's ability to predict cardiovascular risk[26, 27].

ABP is highly cost-effective in children in the initial evaluation of hypertension [28-30]. The cost of providing good control of hypertension in an individual can be up to four times higher using conventional clinical BP measurements [31]. The cost–benefit ratio would be expected to increase, as the cost of managing hypertension rises with increasing rates of diagnosis and prescribing of new, more expensive antihypertensive agents. A study updated a model for calculating the costs of management for hypertension that includes or excludes the use of ABPM to detect sustained hypertension [32].

APPLICATIONS OF ABPM

Various applications of ABPM are shown in **Figure 2.**

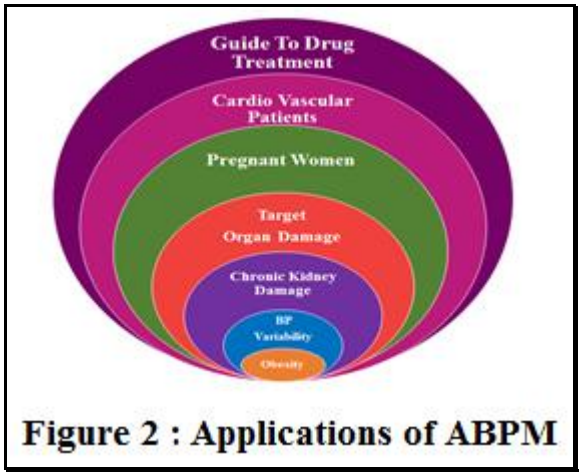


Figure 2 : Applications of ABPM

Blood pressure variability

ABPM is useful in the evaluation of BP variability. 24-hour, non-invasive ABP monitoring estimates cardiac risk factors which includes excessive BP variability or patterns of circadian variability which increase risks of cardiovascular event. There is a need that the activity of both short-term and long-term BP regulatory systems have to meet the changing physical and psychological demands of a normal day. ABPM can provide an index of the regulation of these systems [33].

The variation in 24–hour BP is not only because of a reduction during night sleep but also because of sudden, fast, and short-lasting changes that may occur both during the day and, to a lesser extent, during the night. Some studies showed that when quantified as the standard deviations of the BP values recorded intra-arterially over the 48 half hours of a 24-hour monitoring period, this short-term BP variability increases when BP increases, which can also be seen when normotensive, mild, moderate, and severe hypertensive subjects are compared [34, 35].

In patients with a greater BP variability, overall organ damage and left ventricular mass index increase more at follow-up when compared to those hypertensive patients whose BP variability is less

for the same 24-hour BP mean values [36, 37]. SBP variability was measured by any of the three methods [38]:

- Within-visit variability - difference in CBP values from 3 consecutive BP measurements during the same visit.
- Visit-to-visit BP variability - difference in CBP values between visits.
- Intra-ABPM variability - difference in BP values over a 24-hour period.

Overnight reduction or surge in blood pressure

Optimal BP fluctuates over a 24-hour sleep-wake cycle, with values rising in the daytime and falling after midnight. The reduction in early morning BP compared with average daytime pressure is referred to as the night-time dip. ABPM may reveal a blunted or abolished overnight dip in BP. This information is clinically useful because non-dipping BP is associated with a higher risk of LVH and cardiovascular mortality. By comparing the early morning pressures with average daytime pressures, a ratio can be calculated which owes to assess the relative risk.

Table 3 gives the classification of hypertensive patients based on their ABP measurements. Classification of dipping in BP is based on the American Heart Association's calculation, using SBP as follows-

$$\text{Dip} = \left(1 - \frac{SBP_{Sleeping}}{SBP_{Waking}}\right) \times 100\%$$

TABLE 3. CLASSIFICATION OF DIPPERS

Range	Class
<0%	Reverse Dipper
0% - 10%	Non-Dipper
10% - 20%	Dipper
>20%	Extreme Dipper

Furthermore, ABPM reveals an excessive morning BP surge associated with increased risk of stroke in elderly people with high BP. CV events, such as myocardial infarction, ischemia, and stroke, are more frequent in the morning hours soon after waking compared to other times of day [39]. Circadian variations in biochemical and physiological parameters explain the link between acute Cardiovascular (CV) events and the early morning BP surge [40]. In older hypertensive subjects, a morning surge in BP (a rise in BP >55 mm Hg) from the lowest night-time reading, carries a risk of stroke almost three times greater than that seen in patients without a morning surge [41]. Dippers have significantly higher all-cause mortality than non-dippers or reverse dippers. Based on this evidence one study strongly reported that ABP predicts mortality significantly better than CBP [42].

Dipping and nondipping

The "dipper/nondipper" classification was first introduced in 1988 when a retrospective analysis suggested that majority of nondipping hypertensive patients owe to higher risk of stroke than the patients with a dipping pattern [43]. In general, it is accepted that a fall in nocturnal BP is associated with a poor prognosis [44]. In elderly people with long-standing hypertension, a blunted nocturnal dip in BP is independently associated with lower cognitive performance [45].

In a study, among the elderly patients with recently diagnosed isolated systolic hypertension, those with a nondipping nocturnal pattern have been shown to have significantly higher left ventricular masses on echocardiography than dippers [46]. A nondipping nocturnal pattern is also associated with renal and cardiac target organ involvement. Among all other measures of BP, comparatively nocturnal BP is known to be an independent risk factor for CV outcome [47] which can be supported by the Dublin Outcome Study which suggests that the mortality risk increased by 21% [48] for each 10-mm Hg increase in mean night-time SBP. **Figure 3** shows dipping and nondipping in Blood pressure during 24-hr sleep walk cycle.

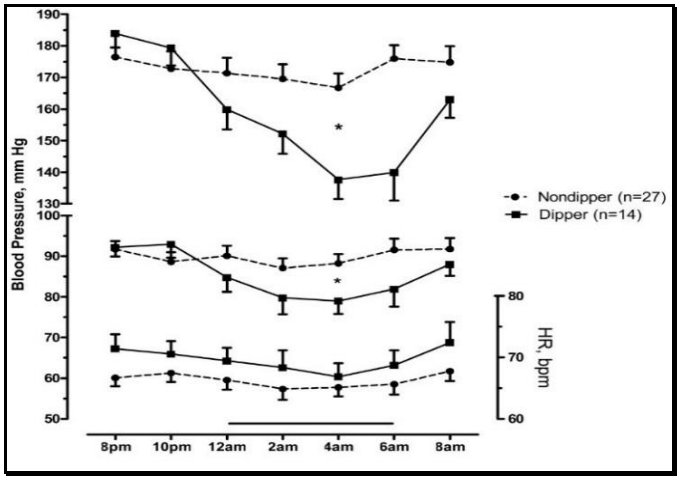


Figure 3. Study by Okamoto, Gamboa. Night time systolic and diastolic blood pressure (left axis), and heart rate (right axis) averaged every two hours from 8PM to 8AM in dippers (solid lines) and non-dippers (discontinued lines). Baseline ("daytime") period Values are expressed as means±SEM. * $p<0.05$, for the difference in mean BP in the sleeping period between dippers and non-dippers [49].

Reverse dipping

In some patients, BP rises above daytime pressures rather than falling during the night. These patients (also referred to as risers, or extreme nondippers) have the worst CV prognosis, both for stroke and cardiac events [50].

Extreme dipping

The converse of nondipping is known as extreme dipping where there is more than 20% reduction in BP at night. Extreme dipper patients experience higher risk for nonfatal ischemic stroke and silent myocardial ischemia with likelihood in those who already have atherosclerotic disease and in whom excessive BP reduction is induced by injudicious antihypertensive medication. This possibility was originally enunciated by Floras in 1988[51]. Extreme dipping is closely associated with an excessive morning surge in BP, which is in turn associated with cerebral infarction and a high risk of future stroke. This is not necessarily benign, as there is evidence to suggest that it may be associated with under perfusion of the brain and mild cognitive impairment in older patients [52], particularly if antihypertensive treatment results in a greater dipping [53].

Siesta dipping

Although, a siesta dip in BP during ABPM is common in societies in which an afternoon siesta is an established practice, in many elderly patients regardless of cultural practice a siesta is often part of the daily routine. Some studies documented that ignoring the dipping pattern associated with a siesta distorts the day/night ratio of ABPM [54] and the magnitude of the siesta dip may have prognostic implications.

Indices of risk in the circadian profile

Based on the evidence of some reviews, ABPM can provide interesting and informative indices that are associated with risk in the circadian profile [55]. These include pulse and mean BP, heart rate, indices of BP variability, chronobiological calculations, Cusum derived statistics, and most recently the ambulatory arterial stiffness index (AASI), which has been shown to predict CV mortality in a large cohort of hypertensive individuals (particularly from stroke).

This association was evident even in normotensive subjects. One study examined a significantly higher relative hazard for CV mortality, especially for stroke mortality which was observed in non-dippers and inverted dippers, whereas in extreme dippers it found to be similar to that in normal dippers. **Figure 4** shows circadian BP variations and several mortalities studied in Ohasama population [56].

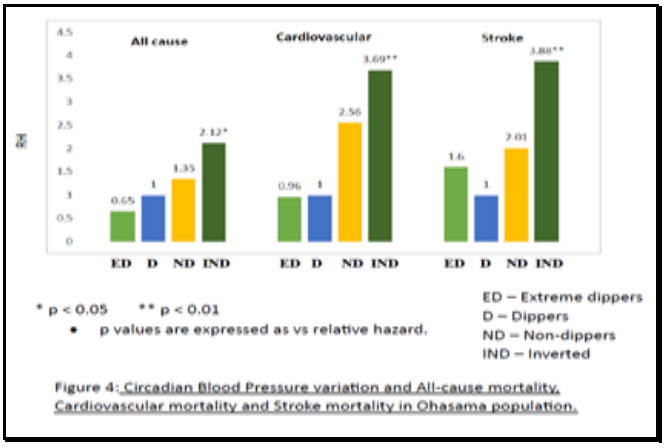


Figure 4: Circadian Blood Pressure variation and All-cause mortality, Cardiovascular mortality and Stroke mortality in Ohasama population.

ABPM in Chronic Kidney Disease (CKD)

BP is a major prognostic indicator in patients with CKD and needs regular monitoring. Round-the-clock monitoring of BP is proven to be a useful clinical biomarker in predicting the outcome of patients suffering from non-dialysis CKD. ABPM can indicate prognosis of patients with CKD by predicting their chances of developing end stage renal disease or cardiovascular events which require hospitalization and even death. Ambulatory BP in adults is also more strongly correlated with renal damage (renal albumin excretion) than is CBP [57]. Albumin to creatinine ratio also relates most strongly DBP variability, which can only be measured with ABPM [58].

ABPM in Target organ Damage

Through ABPM, readings revealing possible hypertension-related end organ damage, such as LVH or narrowing of the retinal arteries are more likely to be gained than through CBP measurement.

In adults, rather than CBP, ABP is more strongly correlated with left ventricular mass (LVM) [59] in both hypertensive and normotensive individuals [60].

Similar results have been published for children, with the relationship greatest between LVM and night-time systolic BP (SBP) and BP load. Similarly, increased carotid intima-media thickness (c-IMT), a risk factor for stroke [61], is associated with ambulatory BP [62], and the relationship between ABPM and c-IMT remains significant even after adjusting for CBP, which suggests that ABPM provides an independent contribution to risk stratification. ABPM is very helpful in stratifying risk for target organ damage, because even with normal average ABPM values, increased BP variability is associated with target organ damage in adults. This may be especially relevant if there is a strong family history of hypertension, because BP variance is under substantial genetic control. Twin and adoptive studies suggest that as much as 50% to 79% of BP variation is due to heredity, although early perinatal events also may play a role.

ABPM in Obesity

It has been clearly established that prevalence of hypertension is increased in overweight and obese subjects. Some mechanisms owing to increased BP in obesity include sympathetic over activity, insulin resistance and sodium retention [63]. The evidence regarding the relationship of fat accumulation and distribution abnormalities with ABPM is very limited and has been limited to either children [64] or small cohorts [65]. The reasons for obesity or abdominal obesity's minimal impact on ABPM are speculative but could be related to several factors, such as lack of physical activity, a limited therapeutical coverage of daily once administered drugs or an incorrect use of normal size cuffs in large arms. Another important issue in obese or abdominally obese subjects is an increase in nocturnal BP and a greater frequency of a blunted nocturnal fall in BP (a non-dipping pattern) [66]. ABPM adds important clinical information to the management of obese hypertensive patients. The detection of both an enhanced white coat phenomenon and the presence of nocturnal hypertension could be relevant in terms of choosing the best therapeutical options that may provide optimal cardiovascular protection [67].

ABPM in Pregnant Women

Hypertension is the most common medical disorder of pregnancy and likely occurs in 10% to 12% of all pregnancies. The accurate measurement of BP is essential [68] because the detection of elevated BP during pregnancy is one of the major aspects of optimal antenatal care.

Mercury sphygmomanometry has been the commonly recommended method for BP measurement during pregnancy. Inspite of some limitations, it is recognized that alternatives to mercury devices may be necessary and a small number of automated BP recorders have been validated for use in pregnancy [69]. Self-monitoring may be useful in evaluating BP changes during pregnancy but it may interfere with daytime activities and also is not feasible during night [70, 71].

These limitations are well compensated by ABPM which allows to follow the time course of BP variation over ≥24 hours in large groups of individuals [72]. As in the non-pregnant state, the main use for ABPM in pregnancy is the identification of white coat hypertension, which may occur in nearly 30% of pregnant women and its recognition is very important so that pregnant women are not admitted to hospital or given antihypertensive drugs unnecessarily or excessively.

Normal mean daytime (awake) ABP values are

- < 132/79mmHg at up to 22 weeks gestation,
- < 133/81mmHg at 26–30 weeks gestation, and
- < 135/86mmHg at more than 30 weeks gestation.

A study documented predictable patterns of BP changes along gestation by the use of ABPM in both clinically healthy and hypertensive pregnant women [73]. According to this study in normotensive women, BP steadily decreases up to the middle of gestation and then increases up to the day of delivery, with final BP values similar to those found early in pregnancy in the same women. For women who developed gestational hypertension or preeclampsia, BP founds to be stable during the first half of pregnancy and then continuously increases until delivery. Despite these differing patterns of BP predictable variation, diagnosis of

hypertension in pregnancy still relies mostly on constant thresholds for BP not specified as a function of gestational age [74, 75].

Moreover some reviews stated that the differences in the circadian pattern of BP, between healthy and complicated pregnancies can be observed by ABPM as early as in the first trimester of pregnancy, before the actual clinical diagnosis of gestational hypertension or preeclampsia takes place for the women investigated [76].

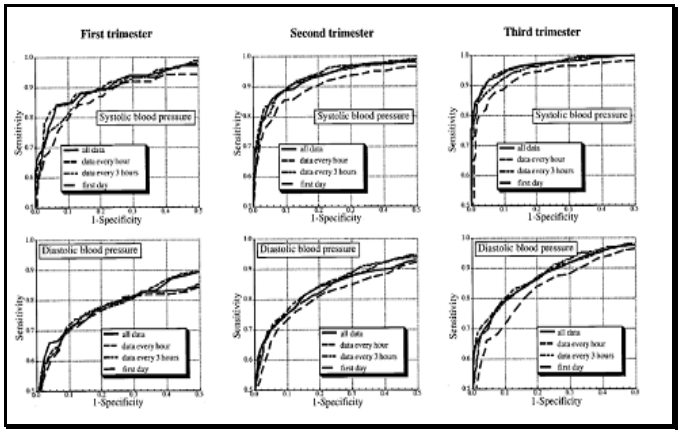


FIGURE 5: Study by Hermida, Ayala. ROC curves for the diagnosis of gestational hypertension and preeclampsia based on 24-hr mean of SBP (top) and DBP (bottom) obtained in different trimesters of pregnancy from data sampled by ambulatory monitoring every 20 to 30min for 48 consecutive hours, every hour for 48 hours, every 3 hours for 48 hours, or every 20 to 30 min for 24 hours only.

Figure 5 shows that sensitivity and specificity [77] in the diagnosis of hypertension in pregnancy are affected by reducing the duration of sampling rather than by reducing the sampling rate [78-80].

ABPM in hypertension and cardiovascular patients

Hypertension is the predominant CV risk indicator in middle-aged and older subjects. The detection and treatment of hypertension is promisingly important to prevent long-term cerebrovascular and cardiovascular complications. Aggressive attempts to identify and treat hypertension must be balanced carefully with the risks of over diagnosis and over treatment in these patients. ABPM is helpful both as a diagnostic tool and in monitoring and adjusting antihypertensive therapy [81].

Investigators in the Ambulatory Blood Pressure Monitoring and Treatment of Hypertension (APTH) trial tested the hypothesis that the use of 24-hour ABPM when compared with conventional measurement would lead to less intensive treatment with drugs and fewer adverse effects, and that control of BP over the whole day would remain preserved in spite of the reduction in the intensity of treatment. **Figure 6** shows care pathway for Hypertension given by NICE clinical guidelines.

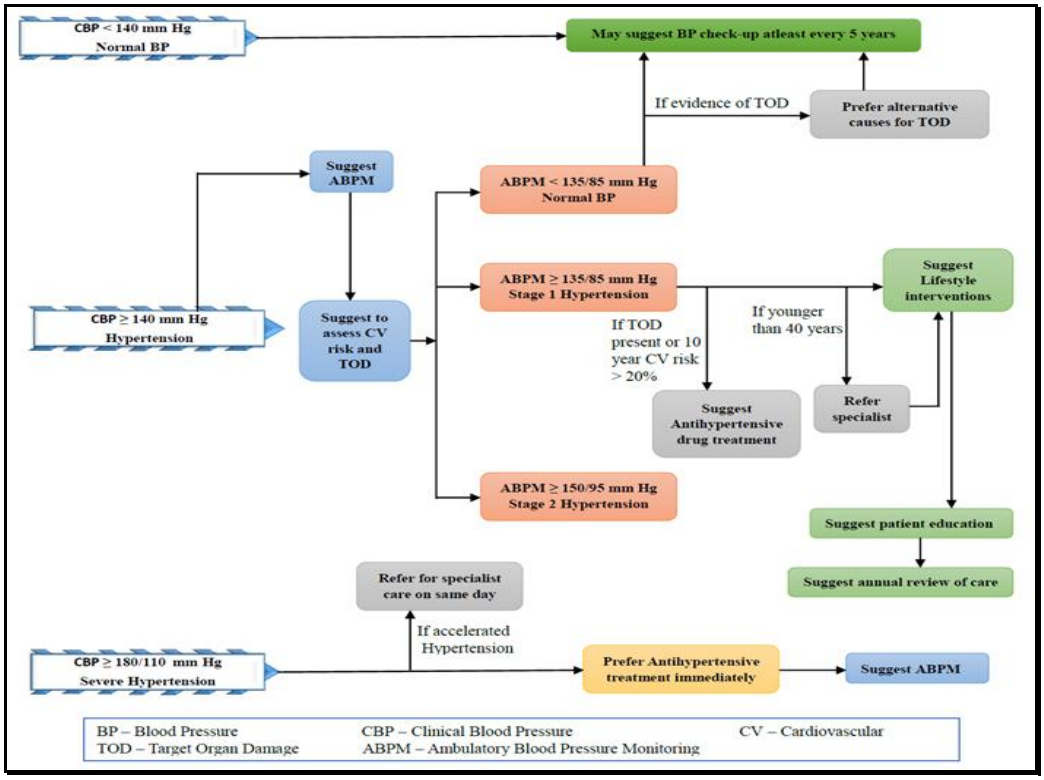


FIGURE 6: CARE PATHWAY FOR HYPERTENSION BASED ON THE NICE CLINICAL GUIDELINES

Secondary hypertension

Secondary hypertension is more common in children than in adults. Hypertension detected in very young children, or in children or adolescents with clinical signs that suggest systemic conditions and the diagnosis of stage 2 hypertension, are all suggestive of secondary hypertension. A clinical study examined that adolescents with secondary hypertension have been shown to manifest greater nocturnal SBP loads and greater daytime and nocturnal DBP loads than children with primary hypertension [82] and concluded that ABPM readings may be useful in differentiating primary from secondary hypertension. Similarly, a study from the Czech Republic demonstrated a decreased nocturnal dipping in children with secondary hypertension [83]. **Table 5** shows the thresholds of hypertension on the basis of Blood pressure measurement method.

TABLE 5: THRESHOLDS FOR VARIOUS STAGES OF HYPERTENSION

Blood pressure measurement method	Threshold for Stage 1 hypertension	Threshold for Stage 2 hypertension
Clinical blood pressure reading	140/90mmHg	160/100mmHg
Ambulatory blood pressure reading	135/85mmHg	150/95mmHg

Masked Hypertension

Another condition that may be uncovered with ABPM is masked hypertension, which is defined as normal CBP but with elevated ambulatory levels. In adults, masked hypertension has been associated with an increased CV risk [84] and with progression of CKD [85]. In children, it is associated with progression to sustained clinical hypertension [86] and higher LVM [87]. Even though carefully conducted home BP monitoring could possibly be used to identify masked hypertension, ABPM is a superior technique and is considered as the gold standard for evaluation of both WCH and masked hypertension. A study stated that the prevalence of masked hypertension in adults seems to be at least 10% and may indeed be higher, with a tendency to decrease with age [88].

Nocturnal Hypertension

ABPM allows BP to be intermittently monitored during sleep, and is useful to determine whether the patient is a dipper or non-dipper (to confirm whether or not BP falls at night compared to daytime values). A night time fall in BP is normal and desirable. It not only correlates with relationship depth but also with other factors such as sleep quality, age, hypertensive status, marital status, and social network support [89].

One study reported that the absence of a night time dip is associated with poorer health outcomes, including increased mortality [90], end organ damage [91]. ABPM is the only non-invasive BP measuring technique that owes the measurement of BP during sleep. Readings are generally recorded every 30 minutes during sleep, and though ABPM may disturb sleep (in some people) it is generally well tolerated. There lies a linear and inverse relation between cardiovascular mortality and the nocturnal decline in BP, which was independent of the overall BP load during 24 hours and other cardiovascular risk factors.

White-coat hypertension

WCH is one more clinical condition in which ABPM data are critical. WCH is defined as BP levels that are the 95th percentile or higher when measured in the physician's clinical or clinical but are completely normal (average BP _90th percentile) outside of a clinical setting. CBP measurements often fail to account for this transient, stress-induced elevation of BP. It has been proved that there lies a strong, direct correlation between the presence of WCH and CBP levels, with the likelihood of WCH decreasing as CBP is increased. Some adult studies found that patients with WCH have lower LVM than those with sustained hypertension; their cardiac mass is higher than that of normal controls [92].

Furthermore, other forms of target organ damage, such as endothelial dysfunction [93] and increased c-IMT [94], are associated with WCH and may account for the increase in adverse CV disease outcomes [95]. Although data in children are sparse, youth with WCH have been shown to have greater body mass index and a tendency towards elevated LVM index, thereby, strengthening the indications for ABPM

follow-up of WCH [96]. **Figure 7** shows the ambulatory patterns of one study [91].

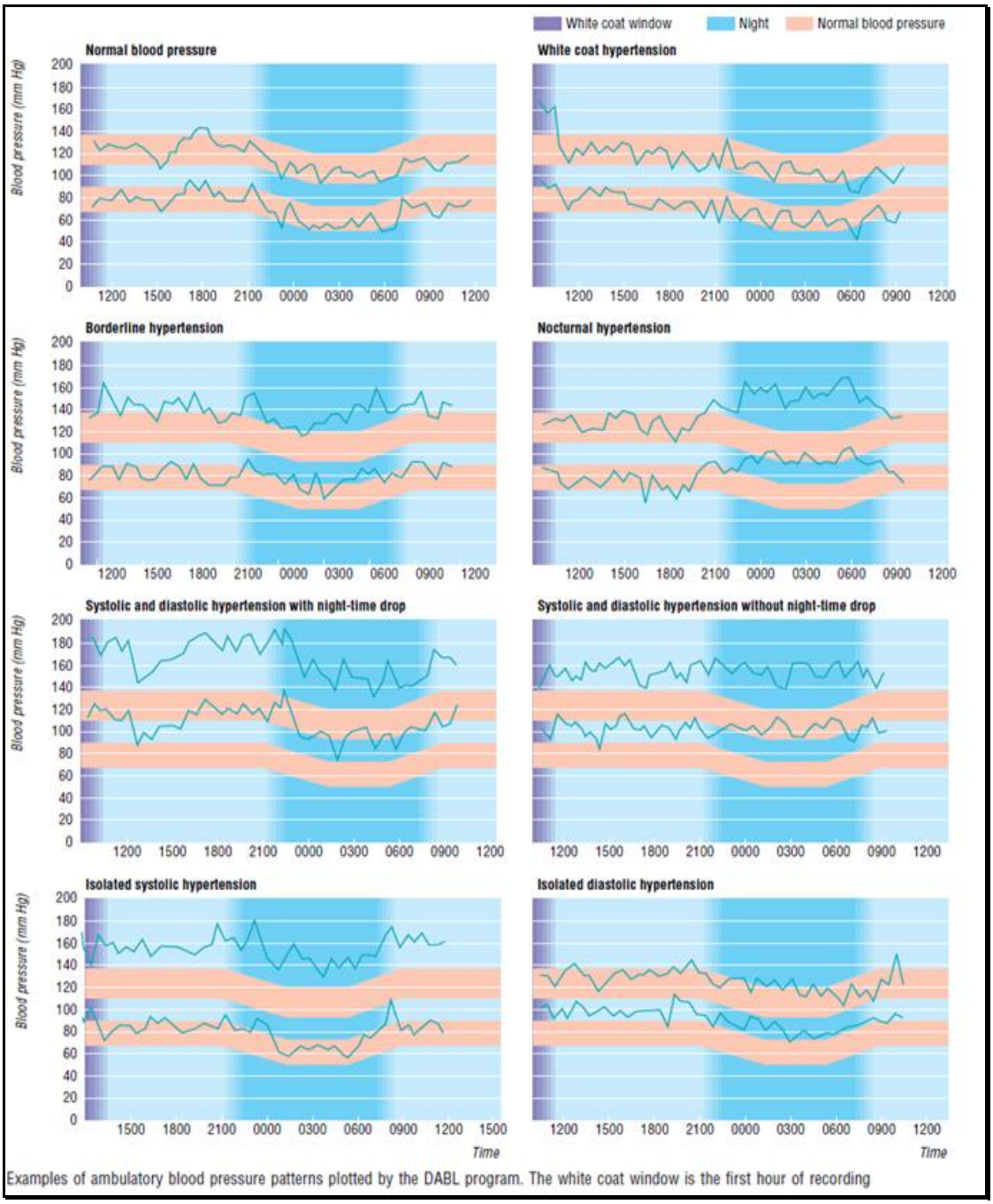


FIGURE 7: VARIOUS AMBULATORY BLOOD PRESSURE PATTERNS STUDIED BY BRIEN AND OWENS

White-coat effect

WCH differs from the "white-coat effect," which is described as the increase in pressure that occurs in the medical environment regardless of daytime ABPM. It can also be explained as the phenomenon found in most hypertensive patients whereby CBP is usually greater than the average daytime ABPM, which is nonetheless increased above normal [97].

Ambulatory hypotension

Hypotension is a condition that is particularly common in the elderly, who may have autonomic or baroreceptor failure and who may also experience postprandial and postural hypotension. ABPM aims in identifying hypotensive episodes in young patients in whom hypotension is suspected of causing symptoms. In treated hypertensive patients, ABPM also demonstrates drug-induced decreases in BP that may have untoward effects in particular patients with compromised arterial circulation, individuals with coronary and CV disease.

Table 6 compares various hypotensive patterns by CBP, ABPM and SBPM.

TABLE 6: COMPARISON OF HYPOTENSIVE PATTERNS BY CLINICAL, AMBULATORY AND SELF BP MONITORING

Hypotensive Patterns	Clinical BP	ABPM	SBPM
Postural hypotension	Difficult to diagnose	Time, duration, and relationship to hypotension can be documented	Fall in standing SBPM
Postprandial hypotension	Difficult to diagnose	Fall in ABPM after meals	Fall in SBPM after meals
Drug-induced hypotension	Difficult to diagnose	Time, duration, and relationship to drug intake can be documented	Can be detected with SBPM after drug ingestion
Idiopathic hypotension	Difficult to diagnose	Best diagnosed with ABPM	Can be detected if SBPM related to hypotension
Autonomic failure	Difficult to diagnose	Daytime hypotension and nocturnal hypertension	Not detectable because of lack of night-time BP

ABPM as a guide to drug treatment

The role of ABPM in guiding drug treatment is currently the subject of much research, and its place in this regard has not yet been fully established. Many reviews have highlighted the potential of 24 hour ABPM in guiding antihypertensive medication. Moreover, in a well-controlled study by Staessen and colleagues, adjustment of antihypertensive treatment based on either ABPM or CBPM resulted in less intensive drug treatment in the ABPM group despite comparable BP control in both groups; highlighting the patients in the ABPM group, who received less drug treatment, were not disadvantaged as based on left ventricular mass on echocardiography.

When short-lasting antihypertensive drugs are administered once a day to lower BP in hypertensive patients, usually in the morning, the early hours of the next morning may be characterized by a steeper BP rise, the physiological changes occurring at waking time being combined with the BP escape from the effects of treatment, a condition that might indeed contribute to a higher risk of cardiovascular events. Thus, the main goal of treatment should probably be not to reduce the slope of the morning BP rise, rather to homogeneously lower the whole 24-hour BP profile, without inducing major differences between the reduction of day and night values, and thus also without any adverse interference with the physiological morning BP rise.

The use of ABPM in the assessment of efficacy of antihypertensive drugs, is as follows-

1. Since there is no significant modification of ABP by the white coat effect, the recruitment on the basis of this approach more adequately selects truly hypertensive individuals and allows the specific assessment of the actual BP lowering effect of a given treatment.
2. With the use of 24-hour ABPM it is possible to determine whether a once-a-day drug dose lower BP throughout the 24 hours in a homogeneous fashion, i.e., without an excessive BP fall early after drug assumption and without a vanning of the hypotensive effect later.

For effective Management of blood pressure [104] using various antihypertensive drugs for various stages of hypertension measured by ABPM and recommended drugs for some compelling indicationsis given in **Tables 7** and **8** respectively.

TABLE 7: MANAGEMENT OF BLOOD PRESSURE USING ANTIHYPERTENSIVE DRUGS

BP Classification	With Compelling Indications	Without Compelling Indications
Prehypertension	No antihypertensive drug indicated	Drug(s) for compelling Indications.*
Stage 1 Hypertension	Thiazide-type diuretics for most. May consider ACEI, ARB, BB, CCB, or combination.	Drug(s) for the compelling Indications.* Other antihypertensive drugs (diuretics, ACEI, ARB, BB, CCB) as needed.
Stage 2 hypertension	Two-drug combination for most+ (usually thiazide-type diuretic and ACEI or ARB or BB or CCB).	

Drug abbreviations:
ACEI - angiotensin converting enzyme inhibitor;
ARB - angiotensin receptor blocker; BB - Beta-blocker; CCB - calcium channel blocker.
+ Initial combined therapy should be used cautiously in those at risk for orthostatic hypotension.
* Treat patients with chronic kidney disease or diabetes to BP goal of <130/80 mmHg.

TABLE 8: RECOMMENDED DRUGS FOR SOME COMPELLING INDICATIONS

Compelling Indication*	Recommended Drugs+					
	Diuretic	BB	ACEI	ARB	CCB	Aldo ANT
Heart failure	✓	✓	✓	✓		✓
Post myocardial infarction		✓	✓			✓
High coronary disease risk	✓	✓	✓		✓	
Diabetes	✓	✓	✓	✓	✓	
Chronic kidney disease			✓	✓		
Recurrent stroke prevention	✓		✓			

* Compelling indications for antihypertensive drugs are based on benefits from outcome studies or existing clinical guidelines; the compelling indication is managed in parallel with the BP.

+ Drug abbreviations: ACEI - angiotensin converting enzyme inhibitor; ARB - angiotensin receptor blocker; Aldo ANT - aldosterone antagonist; BB - beta-blocker; CCB - calcium channel blocker.

ABPM DEVICE AND WORKING

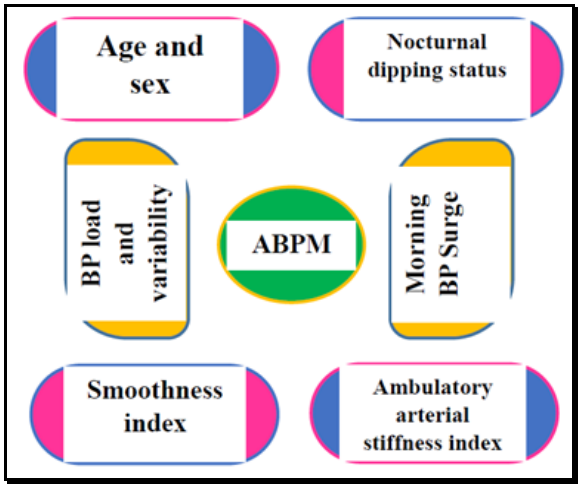
Automatic BP readings at pre-specified intervals (usually every 15 to 20 minutes) within the 24 hour cycle can be recorded by the use of an ambulatory blood pressure monitor. It uses a small digital BP machine attached to a belt around the individual's body and which is connected to a cuff around individual's upper arm. Figure 8 shows an ABPM device.

It is small enough that one can go about normal daily life by wearing on a belt on waist while the cuff stays on upper arm for the full 24 hours and even sleep with it on. The machine then takes BP readings at regular intervals throughout the day: usually, every 15-30 minutes during the daytime and 30-60 minutes at night. The monitor must be kept on throughout the night. The machine can be placed under the pillow or on the bed while sleeping. At the end of the 24 hours the cuff and machine can be removed. The machine will have stored all the readings and these will then be analysed. Since the introduction of ABPM, increasingly automated, lightweight, and accurate measurement devices have emerged. They are typically battery-powered, belt-worn, and of a size and shape similar to that of a Sony Walkman radio. ABPM units indirectly measure BP through auscultation (of Korotkoff's sounds) with piezoelectric microphones, through oscillometric measurement of the vibratory signals associated with blood flow in the brachial artery, or through the combined use of both technologies. Auscultatory devices record both systolic and diastolic pressures, whereas the oscillatory units record systolic and mean pressure and then calculate diastolic pressure through a variety of algorithms.

The cuff is inflated until the pressure occludes flow within the brachial artery. As the pressure is released, blood begins to flow causing fluctuations (oscillations) in the arterial wall that are detected by the monitor. These oscillations increase in intensity then diminish and cease when blood is flowing normally. The monitor defines the maximal oscillations as mean arterial BP and then uses an algorithm to calculate systolic and diastolic BP.

Factors to Be Considered When Interpreting Ambulatory Blood Pressure Readings

Figure 9 describes the factors to be considered when interpreting ambulatory blood pressure readings.



CONCLUSIONS: High blood pressure is one of the most important and preventable causes of premature ill health and death in the world. It is a major risk factor for stroke, heart attack, heart failure, chronic kidney disease and cognitive decline. The hypertension may be related, in part, to obesity, dietary factors such as salt intake, physical inactivity or genetic inheritance. The risk associated with increasing BP is continuous, with each 2 mmHg rise in SBP associated with a 7% increased risk of mortality from ischaemic heart disease and a 10% increased risk of mortality from stroke. The usage of ABPM as a diagnostic strategy for high BP is more effective in terms of making a diagnosis and treatment; providing therapeutic efficacy and saving costs. ABPM is likely to eliminate ambiguity in selection of suitable drug for the hypertensive treatment.

Using ABPM to diagnose hypertension is not only more effective than testing blood pressure at home or in the clinical, it also eliminates administration of drugs in which BP is normal. ABPM will reduce costs by cutting down on unnecessary treatment, and also provide a diagnosis more effectively. Patients will benefit because people with genuine high BP can be picked up and treated sooner, and those who get anxious when seeing a doctor, but don't have consistently high BP, won't be in danger of being prescribed medicines which they don't need.

ACKNOWLEDGEMENTS: Any attempt at any level cannot be satisfactorily completed without the support and guidance of learned people and an encouraging environment. It's a pleasure that I have a chance to express my gratitude to everyone who helped me through the course of my attempt. I wish to express my heartfelt gratitude and indebtedness to my institution, Vignan Pharmacy College and Dr. Lavu Rathaiah group of institutions for the support during the course of my work.

REFERENCES:

1. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J: Global burden of hypertension: analysis of worldwide data. *Lancet*2005; 365:217-223.
2. N. Poulter: Improving the management of hypertension. Medicographia 2010; 3: 226-232.
3. Whelton PK. Hypertension curriculum review: epidemiology and the prevention of hypertension. *J Clin Hypertens (Greenwich)* 2004; 6:636-642.
4. Thomas GN, Chan P, Tomlinson B: The role of angiotensin II type 1 receptor antagonists in elderly patients with hypertension. Drugs Aging 2006; 23(2):131-55.
5. J M Flack: Maximising antihypertensive effects of angiotensin II receptor blockers with thiazide diuretic combination therapy: focus on irbesartan/hydrochlorothiazide. International Journal of Clinical Practice 2007 December; 61(12): 2093-2102.
6. Sanjay Karala, BhartiKalra: Combination therapy in hypertension: An update. *Diabetology & Metabolic Syndrome* 2010.
7. Jennifer Frank: Managing Hypertension Using Combination Therapy. American Academy of Family Physician 2008 May; 77(9):1279-1286.
8. O'Brien E: ABPM blood pressure measurement is indispensable to good clinical practice. *J Hypertension*2003; 21:S11-S18.
9. Clement DL, De BuyzereML, De Bacquer DA, de Leeuw PW: Clinical versus 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. Perloff D, Sokolow M, Cowan R: The prognostic value of ambulatory blood pressure monitoring in treated hypertensive patients. *J Hypertens Suppl* 1991; 9:S33-S39.
11. Ohkubo T, Imai Y, Tsuji I, Nagai K, Watanabe N, Minami N: Relation between nocturnal decline in blood pressure and mortality. The Ohasama Study.*Am J Hypertens* 1997; 10:1201-1207.
12. Staessen J, Thijs L, Fagard R, O'Brien E, Clement D, deLeeuw PW: 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.
13. G. Pickering and B. White: When and how to use self (home) and ambulatory blood pressure monitoring. *Journal of the American Society of Hypertension* 2008; 2(3): 119-124.
14. Kenny RA, Brenman M, O'Malley K, O'Brien E: Blood pressure measurements in borderline hypertension. *J Hypertens*1987; 5(suppl):S483-S485.
15. Bialy GB: Comparison of clinical, home and 24-hour ambulatory blood pressures in borderline and mild hypertension. *Angiology*1988; 39:752-760.
16. James GD, Pickering TG, Yee LS, Harsfield GA, Riva S, Laragh JH: The reproducibility of average ambulatory, home, and clinical pressure.*Hypertension*1988; 11:545-549.
17. O'Brien E, Fitzgerald D, O'Malley K: Comparison of clinical, home and ambulatory blood pressure measurement. *J Ambulatory Monitoring*1988; 1:285-291.
18. Little P, Barnett J, Barnsley L, Marjoram J, Fitzgerald-Barron A, Mant D: Comparison of agreement between different measures of blood pressure in primary care and daytime ambulatory blood pressure. *BMJ*2002; 325:254.
19. Appel LJ, Stason WB: Ambulatory blood pressure monitoring and blood pressure self-measurement in the diagnosis and management of hypertension. *Ann Intern Med* 1993; 118:867-882.
20. Uallachain GN, Murphy G, Avalos G: The RAMBLER Study: the role of ambulatory blood pressure measurement in routine clinical practice: a cross-sectional study. *Ir Med J*2006; 99:276-279.
21. Banegas JR, Segura J, Sobrino J, Rodrıguez-Artalejo F, Ruilope LM: for the Spanish Society of Hypertension Ambulatory BP Monitoring Registry Investigators. Effectiveness of blood pressure control outside the medical setting.*Hypertension* 2007; 49:62-68.
22. Gorostidi M, Sobrino J, Segura J, Sierra C, de la Sierra A, Ruilope LM: on behalf of the Spanish Society of Hypertension ABPM Registry investigators. Ambulatory blood pressure monitoring in hypertensive patients with high cardiovascular risk: a cross-sectional analysis of a 20000-patient database in Spain. *J Hypertens* 2007; 25:977-984.

23. Bjorklund K, Lind L, Zethelius B: Prognostic significance of 24-h ambulatory blood pressure characteristics for cardiovascular morbidity in a population of elderly men. J Hypertens 2004; 22: 1691-1697.
24. Khattar RS, Swales JD, Dore C: Effect of aging on the prognostic significance of ambulatory systolic, diastolic, and pulse pressure in essential hypertension. Circulation 2001; 104:783-789.
25. National High Blood Pressure Education Program Working Group report on ambulatory blood pressure monitoring. Arch Intern Med 1990; 150:2270-2280.
26. Pickering TG: Ambulatory blood pressure monitoring in clinical practice. ClinCardiol 1991; 14:557-562.
27. White WB: How well does ambulatory blood pressure predict target-organ disease and clinical outcome in patients with hypertension? Blood Press Monit 1999; 4(suppl 2):S17-S21.
28. Krakoff LR: Cost-effectiveness of ambulatory blood pressure: a reanalysis. *Hypertension* 2006; 47:29-34.
29. White WB: Expanding the use of ambulatory blood pressure monitoring for the diagnosis and management of patients with hypertension. *Hypertension* 2006; 47:14-15.
30. Swartz SJ, Srivaths PR, Croix B, Feig DI: Cost-effectiveness of ambulatory blood pressure monitoring in the initial evaluation of hypertension in children. Pediatrics 2008; 122:1177-1181.
31. Rodriguez-Roca GC, Alonso-Moreno FJ, Garcia-Jimenez A, Hidalgo- Vega A, Llisterri-Caro JL, Barrios-Alonso V: Cost-effectiveness of ambulatory blood pressure monitoring in the follow-up of hypertension. Blood Press 2006; 15:27-36.
32. Verdecchia P, Porcellati C, Schillaci G, Borgioni C, Ciucci A: Ambulatory blood pressure: an independent predictor of prognosis in essential hypertension. *Hypertension* 1994; 24:793-801.
33. Harshfield GA, Pickering TG, Kleinert HD, Blank S, Laragh JH: Situational variations of blood pressure in ambulatory hypertensive patients. *Psychosom Med* 1982; 44:237-245.
34. Mancia G, Parati G, Di Rienzo M, Zanchetti A: Blood pressure variability. *Pathophysiology of Hypertension (Handbook of Hypertension Vol. 17)*. Elsevier Science 1997; 117-169.
35. Mancia G, Ferrari A, Gregorini L, Parati G, Pomidossi G: Blood pressure and heart rate variabilities in normotensive and hypertensive human beings. *Circ Res*1983; 53:96-104.
36. Frattola A, Parati G, Cuspidi C, Albini F, Mancia G: Prognostic value of 24-hour blood pressure variability. *J Hypertens* 1993; 11:1133-1137.
37. Verdecchia. Verdecchia P, Borgioni C, Ciucci A: Prognostic significance of blood pressure variability in essential hypertension. *Blood Press Monit* 1996 Feb; 1:3-11.
38. Imholz BPM, Langewouters GJ, Van Montfrans GA, Parati G, Van Goudoever J, Wesseling KH: Feasibility of ambulatory, 24-hour-continuous, finger arterial pressure recording. *Hypertension* 1993; 21:65-73.
39. Giles T: Relevance of blood pressure variation in the circadian onset of cardiovascular events. *J Hypertens* 2005; 23(suppl 1):S35-S39.
40. Giles TD: Circadian rhythm of blood pressure and the relation to cardiovascular events. *J Hypertens* 2006 24(suppl 2):S11-S16.
41. KarioK, Pickering TG, Umeda Y: Morning surge in blood pressure as a predictor of silent and clinical cerebrovascular disease in elderly hypertensives: a prospective study. *Circulation* 2003; 107:1401-1406.
42. Ben-Dov, Iddo Z, Jeremy D. Kark, Drori Ben-Ishay, Judith Mekler, Liora Ben-Arie, (March 26, 2007):"Blood Pressure Measurement and Cardiovascular Risk Predictors of All-Cause Mortality in Clinical Ambulatory Monitoring Unique Aspects of Blood Pressure during Sleep". *Hypertension* 2013; 49: 1235-1241.
43. O'Brien E, Sheridan J, O'Malley K: Dippers and non-dippers [letter].Lancet 1988; ii: 397
44. Staessen J, Bulpitt CJ, Fagard R: Reference values for the ambulatory blood pressure and the blood pressure measured at home: a population study. *J Hum Hypertens*1991; 5:355-361.
45. Mousa T, El-Sayed MA, Motawea AK, Salama MA, Elhendy A: Association of blunted night-time blood pressure dipping with coronary artery stenosis in men. *Am J Hypertens*2004; 17:977-980.
46. Bellelli G, Frisoni GB, Lucchi E: Blunted reduction in night-time blood pressure is associated with cognitive deterioration in subjects with long-standing hypertension. *Blood Press Monit*2004; 9:71-76.
47. Cicconetti P, Morelli S, Ottaviani L: Blunted nocturnal fall in blood pressure and left ventricular mass in elderly individuals with recently diagnosed isolated systolic hypertension. *Am J Hypertens*2003; 16:900-905.
48. Kikuya M, Ohkubo T, Asayama K: Ambulatory blood pressure and 10-year risk of cardiovascular and noncardiovascular mortality. The Ohasama Study. *Hypertension* 2005; 45:240-245.
49. Luis E. Okamoto, Alfredo Gamboa, CyndyaShibao: Nocturnal blood pressure dipping in the hypertension of autonomic failure.
50. Kario K, Shimada K: Risers and extreme-dippers of nocturnal blood pressure in hypertension: antihypertensive strategy for nocturnal blood pressure. *ClinExpHypertens*2004; 26:177-189.
51. Floras JS: Antihypertensive treatment, myocardial infarction, and nocturnal myocardial ischaemia. *Lancet*1988; 2:994-996.
52. Guo H, Tabara Y, Igase M, Yamamoto M, and Ochi N, Kido T: Abnormal nocturnal blood pressure profile is associated with mild cognitive impairment in the elderly: the J-SHIPP study. Hypertens Res 2010; 33:32-36.
53. Kario K, Pickering TG, Matsuo T, Hoshide S, Schwartz JE, Shimada K: Stroke prognosis and abnormal nocturnal blood pressure falls in older hypertensives. Hypertension 2001; 38:852-857.
54. Stergiou GS, Malakos JS, Zourbaki AS, Achimastos AD, Mountokalakis TD: Blood pressure during siesta: effect on 24-h ambulatory blood pressure profiles analysis. *J Hum Hypertens*1997; 11:125-131.
55. O'Brien E: Assessment of circadian cardiovascular risk with ambulatory blood pressure measurement. In: Mancia G, ed. *Manual of Hypertension of the European Society of Hypertension* 2007.
56. Ohkubo.T, Nagai.K, Sekino. M: Relation between nocturnal decline in blood pressure and mortality: The Ohasamastudy.Am. J. Hypertens 10: 1201-1207.
57. Palatini P, Mormino P, Santonastaso M, Mos L, Pessina AC: Ambulatory blood pressure predicts end-organ damage only in subjects with reproducible recordings. HARVEST Study Investigators. Hypertension and Ambulatory Recording Venetia Study.*J Hypertens* 1999; 17:465-473.
58. Veerman DP, de Blok K, van Montfrans A: Relationship of steady state and ambulatory blood pressure variability to left ventricular mass and urinary albumin excretion in essential hypertension. *Am J Hypertens* 1996; 9:455-460.
59. Belsha CW, Wells TG, McNiece KL, Seib PM, Plummer JK, Berry PL:Influence of diurnal blood pressure variations on target organ abnormalities in adolescents with mild essential hypertension.*Am J Hypertens* 1998; 11:410-417.
60. Verdecchia P: White-coat hypertension in adults and children. *Blood Press Monit*1999; 4:175-179.
61. O'Leary DH, Polak JF, Kronmal RA, Manolio TA, Burke GL, Wolfson SK Jr: Carotid-artery intima and media thickness as a risk factor for myocardial infarction and stroke in older adults: Cardiovascular Health Study Collaborative Research Group. *N Engl J Med* 1999; 340:14-22.
62. Khattar RS, Acharya DU, Kinsey C, Senior R, Lahiri A: Longitudinal association of ambulatory pulse pressure with left ventricular mass and vascular hypertrophy in essential hypertension. *J Hypertens* 1997; 15:737-743.

63. Mikhail N, Golub MS and Tuck ML: Obesity and hypertension. Prog Cardiovasc Dis 1999; 42: 39-58.
64. Lurbe E, Torro I, and Aguilar F: Added impact of obesity and insulin resistance in nocturnal blood pressure elevation in children and adolescents. Hypertension 2008; 51: 635-641.
65. Helvaci MR, Kaya H, Yalcin A: Prevalence of white coat hypertension in underweight and overweight subjects. Int Heart J 2007; 48: 605-613.
66. De la Sierra A, Redon J, Banegas JR: Prevalence and factors associated with circadian blood pressure patterns in hypertensive patients. Hypertension 2009; 53: 466-472.
67. Alejandro de la Sierra, Luis M. Ruilope: Ambulatory blood pressure in obesity. CMR Journal 2(1): 31-36.
68. Wuhl E, Witte K, Soergel M, Mehls O, Schaefer F, KirschsteinM: Distribution of 24-h ambulatory blood pressure in children: normalized reference values and role of body dimensions. *J Hypertens* 2002; 20:1995-2007.
69. Brown MA, Davis GK: Hypertension in pregnancy. In: ManciaG,Chalmers J, Julius S, Saruta T, Weber MA, Ferrari AU, Wilkinson IB, ed. *Manual of Hypertension* 2002; 579-597.
70. Waugh JJ, Halligan AW, Shennan AH: Ambulatory monitoring andself-monitoring of blood pressure during pregnancy. *Blood Press Monit*2000; 5:3-10.
71. Feldman DM: Blood pressure monitoring during pregnancy. *Blood Press Monit*.2001; 6:1-7.
72. Kyle PM, Clark SJ, Buckley D, Kissane J, Coats AJS, De Swiet M, and Redman CWG: Second trimester ambulatory blood pressure in nulliparous pregnancy: a useful screening test for pre-eclampsia? *Br J Obstet Gynaecol* 1993; 100:914-919.
73. Ayala DE, Hermida RC, Mojón A, Fernández JR, Silva I, Ucieda R, Iglesias M: Blood pressure variability during gestation in healthy and complicated pregnancies. *Hypertension* 1997; 30:611-618.
74. Davey DA, Mac Gillivray I: The classification and definition of the hypertensive disorders of pregnancy. *Am J Obstet Gynecol* 1988; 158: 892-898.
75. National High Blood Pressure Education Program Working Group Report on High Blood Pressure in Pregnancy. *Am J Obstet Gynecol* 1990; 163: 1689-1712.
76. Hermida RC, Ayala DE, Mojón A, Fernández JR, Alonso I: Blood pressure patterns in normal pregnancy, gestational hypertension, and preeclampsia. *Hypertension* 2000; 36:149-158.
77. Hermida RC: Time-qualified reference values for 24 h ambulatory blood pressure monitoring. *Blood Press Monit* 1999; 4:137-147.
78. Higgins JR, Walshe JJ, Halligan A, O'Brien E, Conroy R, Darling MRN: Can 24-hour ambulatory blood pressure measurement predict the development of hypertension in primigravidae? *Br J Obstet Gynaecol* 1997; 104:356-362
79. Bellomo G, Narducci PL, Rondoni F, Pastorelli G, Stangoni G, Angeli G, Verdecchia P: Prognostic value of 24-hour blood pressure in pregnancy.*JAMA* 1999 282:1447-1452
80. Brown MA, Bowyer L, McHugh L, Davis GK, Mangos GJ, and Jones M: Twenty-four-hour automated blood pressure monitoring as a predictor of preeclampsia. *Am J ObstetGynecol* 2001; 185:618-622.
81. Hansen TW, Jeppesen J, Rasmussen S, Ibsen H, Torp-Pedersen C: Ambulatory blood pressure monitoring and risk of cardiovascular disease: a population based study. Am J Hypertens 2006, 19:243-250.
82. Flynn JT: Differentiation between primary and secondary hypertension in children using ambulatory blood pressure monitoring. *Pediatrics* 2002; 110:89-93.
83. Seeman T, Palyzová D, Dusek J, Janda J: Reduced nocturnal blood pressure dip and sustained night-time hypertension are specific markers of secondary hypertension. *J Pediatr* 2005; 147:366-371.
84. Bjorklund K, Lind L, Zethelius B: Isolated ambulatory hypertension predicts cardiovascular morbidity in elderly men.*Circulation* 2003; 107:1297-1302
85. Agarwal R, Andersen MJ: Prognostic importance of clinical and home blood pressure recordings in patients with chronic kidney disease. *Kidney Int* 2006; 69:406-411.
86. LurbeE, Torro I, Alvarez V, Nawrot T: Prevalence, persistence, and clinical significance of masked hypertension in youth. *Hypertension* 2005; 45:493-498.
87. Stabouli S, Kotsis V, Toumanidis S, Papamichael C, Constantopoulos A, Zakopoulos N: White-coat and masked hypertension in children: association with target-organ damage. *PediatrNephrol* 2005; 20:1151-1155.
88. Elaine Urbina, Bruce Alpert: Ambulatory Blood Pressure Monitoring in Children and Adolescents. The journal of The American Heart Associatio. *Hypertension* 2008 52:433-451.
89. Holt-Lunstad J, Jones BQ, Birmingham W: The influence of close relationships on nocturnal blood pressure dipping. Int J Psychophysiol2009; 71(3):211-217.
90. Minutolo R, Agarwal R, Borrelli S, Chiodini P: Prognostic role of ambulatory blood pressure measurement in patients with nondialysis chronic kidney disease. Arch Intern Med 2011; 171(12):1090-1098.
91. O'Brien, Owens. P: Use and interpretation of ambulatory blood pressure monitoring: recommendations of the British Hypertension Society. BMJ 2000; 320: 1128-1133.
92. Palatini P, Mormino P, Santonastaso M, Mos L, Dal Follo M, ZanataG, and Pessina AC: Target-organ damage in stage I hypertensive subjects with white coat and sustained hypertension: results from the HARVEST study. *Hypertension* 1998; 31:57-63.
93. Gómez-Cerezo J, Ríos Blanco JJ, SuárezGarcía I, Moreno Anaya P: Noninvasive study of endothelial function in white coat hypertension. *Hypertension*2002; 40:304-309.
94. Landray MJ, Sagar G, Murray S, Beevers M, Beevers DG, Lip GY: Whitecoat hypertension and carotid atherosclerosis. *Blood Press* 1999; 8:134-140.
95. Gustavsen PH, Hoegholm A, Bang LE, Kristensen KS: White coat hypertensionis a cardiovascular risk factor: a 10-year follow-up study. *J Hum Hypertens* 2003; 17:811-817.
96. Kavey RE, Kveselis DA, Atallah N, Smith FC: White coat hypertension in childhood: evidence for end-organ effect. *J Pediatr* 2007; 150-157.
97. O'Brien E, Asmar R, Beilin L: on behalf of the European Society of Hypertension Working Group on Blood Pressure Monitoring. European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. *J Hypertens*2003; 21:821-848.

How to cite this article:
Sirisha PL Babu GK, Babu PS and Koteswari P: Ambulatory Blood Pressure Monitoring: A Non-Invasive Gold Standard for Hypertensive Therapy. Int J Pharm Sci Res 2014; 5(12): 5073-87.doi: 10.13040/IJPSR.0975-8232.5 (12).5073-87.