REVIEW

Essentials of Ambulatory Blood Pressure Monitoring (ABPM)

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Hypertension is the commonest risk factor for the most common cause of deaths in Sri Lanka; coronary heart disease, stroke, heart and renal failure. Nearly one-fifth to one-third of adult Sri Lankans have blood pressure levels that that are above normal and the prevalence is comparable to those in the developed countries[1,2,3].

Hypertension is diagnosed by either clinic based measurement of blood pressure (Office readings) or by means of out of office blood pressure readings. Out-of-office measurements are highly recommended as an adjunct to office measurements by almost all hypertension associations. The blood pressure measurements could be measured either through Home based self-monitoring (HMBP) or Ambulatory Blood Pressure Monitoring (ABPM). Whenever, HMBP and /or ABPM is used, the various blood pressure targets given for clinic measurements are lowered by 5 mm Hg (eg Hypertension is diagnosed at SBP >135 mm Hg or DBP >85 mm Hg).

Ambulatory blood pressure monitoring (ABPM) measures blood pressure at regular intervals automatically over 24 hours. During the monitoring, the patient remains ambulatory and continues with his/her normal range of daily activities. Several ABPM devices are available and consist fundamentally of a digital blood pressure worn around the waist and connected to an upper arm cuff. Since the BP is measured at regular intervals and averaged over a defined time period.

An ABPM is recommended in the following clinical situations

1. *Diagnosis of hypertension* including white coat hypertension, unusual variability of blood pressure and evaluation of

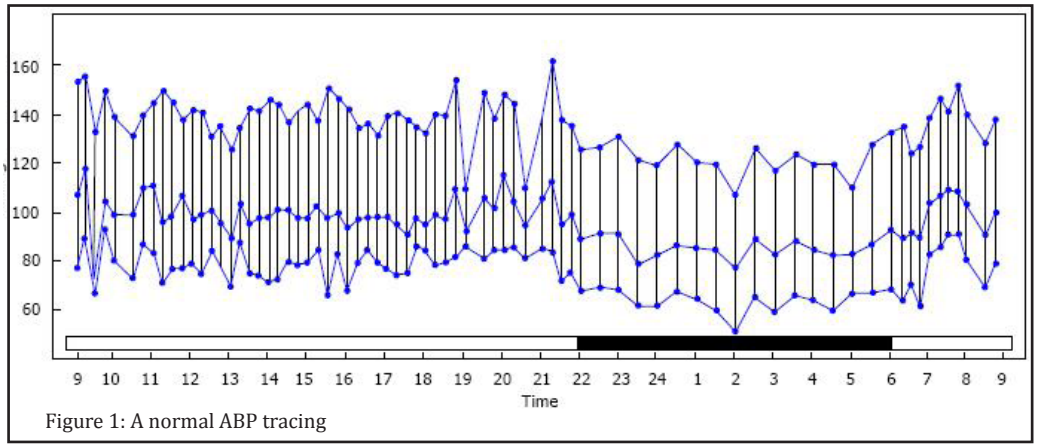

Figure 1: A normal ABP tracing

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nocturnal hypertension (see "dippers and non-dippers")

2. *During treatment of established hypertension* including the assessments of efficacy of anti-hypertensive medications over 24 hrs., symptomatic hypotension and drug resistant hypertension
3. *Diagnosis and treatment of hypertension*
4. *in pregnancy*

Practical approach

For a correct interpretation of ambulatory blood pressure profile, we need to evaluate ambulatory blood pressure components (systolic, diastolic and pulse pressure) comparing them with reference values.Though ambulatory blood pressure tracings can give rise to numerous deductions and inferences there are four important aspects should be kept in mind while interpreting an ambulatory blood pressure. Which can be remembered by a nemonic[4]: Ambulatory Does Prediction Valid (ADPV):

- Average ambulatory blood pressure
- Dipping pattern
- Pulse pressure
- Variability of night-time systolic blood pressure

Cutoff values of hypertension

Blood pressure categories in the new guideline published by ACC/AHA in 2017 are as follows[5]:

- Normal: Less than 120/80 mm Hg;
- Elevated: Systolic between 120-129 *and* diastolic less than 80;
- Stage 1: Systolic between 130-139 *or* diastolic between 80-89;
- Stage 2: Systolic at least 140 *or* diastolic at least 90 mm Hg;
- Hypertensive crisis: Systolic over 180 and/or diastolic over 120, with patients needing prompt changes in medication if there are no other indications of problems, or immediate hospitalization if there are signs of organ damage.

However there are no recent data published regarding the cut off values for ambulatory blood pressure values. JNC7 guidelines and ESC/ESH guidelines published in 2007 points out that the cut off values for average ABP [6,7]. Obviously the cut off values for ambulatory blood pressure is much lesser than the office blood pressure values. Therefore it is reasonable to assume that the cut off values of ambulatory blood pressure could be further reduced based on the recent ACC/AHA guidelines. Cut off values for ambulatory blood pressure are:

24 hours- >130/80
Day time- >135/85
Night time >120/70

Dippers and non-dippers

ABPM allows blood pressure to be intermittently monitored during sleep, and is useful to determine whether a patient is a dipper or non-dipper. A variable extent of night time fall in blood pressure is often seen and is a desirable event (Figure 1). The individuals exhibiting this phenomenon are called dippers. In the absence of a significant night time dip, the patient is labelled a non-dipper.

Dipping patterns are further categorized by the extent of the nocturnal drop in blood pressure relative to the daytime pressure: non-dipper, dipper, extreme dipper and reverse dipper. A reverse dipper is a patient whose nocturnal blood pressure is higher than the average day time blood pressure.

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

Figure 2. Classification of dipping in blood pressure using systolic blood pressure [8]

The assessment of the phenomenon of dipping is useful in defining cardio vascular outcomes and mortality and ABPM could therefore be a better predictor of health outcomes and mortality than clinic measurements[9]. Dippers have significantly lower all-cause mortality than non-dippers or reverse dippers. Furthermore, left ventricular hypertrophy and cardiovascular mortality are high among non-dippers whilst nocturnal hypertension (reverse dipping) is associated with significant target organ damage. ABPM may additionally reveal an excessive morning surge of blood pressure which has been shown to be associated with increased risk of stroke in elderly hypertensives.

Ambulatory pulse pressure

Office pulse pressure is a major predictor of cardiovascular risk in the general population, in patients with hypertension, and in survivors of acute myocardial infarction. The rise in pulse pressure with age may indicate a gradual increase in the stiffness of the large arteries, which is mostly an effect of progression of atherosclerotic lesions. Ambulatory pulse pressure was an important independent predictor of total cardiovascular risk in initially untreated subjects with essential hypertension in a large randomized controlled study[10]. These data indicate that ambulatory pulse pressure is a more accurate marker than office pulse pressure of increased arterial stiffness or already diseased arteries.

Variability of blood pressure

Visit to visit variability of blood pressure in patients attending outpatient medical clinics and night time variability of both systolic and diastolic blood pressure are recently thought to be as important risk factors irrespective of the blood pressure levels. Night-time variability of blood pressure is positively associated with age, BMI, smoking, diabetes mellitus, and average night-time BP. It is an independent predictor of all-cause mortality,cardiovascular mortality,and cardiovascular events. In contrast, daytime BP variability was not an independent predictor of outcomes in studies. A night-time systolic BP variation of ≥12.2 mm Hg was associated with almost 40% greater risk of cardiovascular events, a 55% greater risk of cardiovascular death, and a 59% increased risk of all-cause mortality. The corresponding values for a diastolic BP of ≥7.9 mm Hg were 48%, 132%, and 77%. ABPM is mandatory to identify this special risk population[11,12.]

Ambulatory combined with office readings

Combination of office blood pressure with ambulatory blood pressure may identify four different clinical categories of subjects[11] as shown in figure 3.

a. Subjects normotensive by both methods (true normotension)
b. Subjects hypertensive by both methods (true hypertension)
c. Subjects who are hypertensive based on office blood pressure and normotensive by ambulatory blood pressure (white-coat hypertension)
d. Subjects who are normotensive by clinic blood pressure and hypertensive by ambulatory blood pressure (masked hypertension)

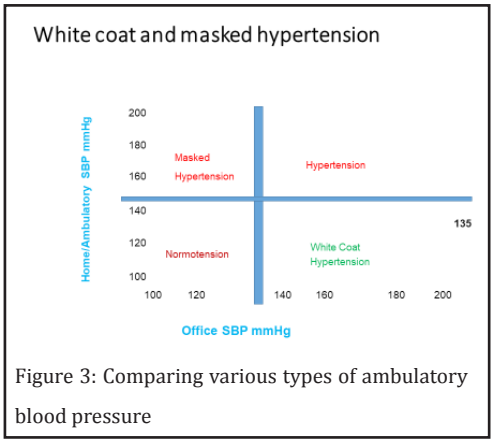

Figure 3: Comparing various types of ambulatory blood pressure

Pregnancy and ambulatory blood pressure

The key role of ambulatory blood pressure in pregnancy is to identify white coat hypertension; the incidence is around 30% of pregnant women. Identifying it is important so that pregnant women are not given antihypertensive medications unnecessarily. The values for ambulatory blood pressure among pregnant women are different , and the changes in pressure which occur during the different trimesters of pregnancy and in the postpartum period have been identified. The evidence that ambulatory measurement may predict pre-eclampsia is not conclusive. However, ambulatory blood pressure correlates better with proteinuria than does conventional blood pressure measurements, and it is a better predictor of complications of hypertension. In addition, women diagnosed with hypertension by ambulatory monitoring have infants with lower birth weights and this association is not found when blood pressure is measured conventionally. Moreover, women with white coat hypertension tend to be more likely to have a caesarean section than women with normal blood pressure, suggesting that if ambulatory measurement was used rather than conventional measurement, some caesarean deliveries could have been avoided[13].

Measurement of ambulatory blood pressure

Ambulatory blood pressure measurements were initially employed in early 1960s. Since then the equipment and the method have gone through different stages of evolution. Principally the ambulatory blood pressure monitor measures blood pressure at regular intervals with subjects under taking their usual activities. Emphasis is made on mean day time blood pressure which is a better predictor of cardiovascular risk and target organ damage than clinic readings. And also an ABPM report gives more details and deductions than either a home or clinic reading[14].

As ambulatory blood pressure is non-invasive, it can be performed in most of the subjects those who need it except for few exceptional circumstances include a non-cooperative patient, severe office hypertension with blood pressure levels exceeding 220/120 mm Hg, an arm too big (above 48-50 cm) to wrap the cuff, severe peripheral vascular disease or thrombocytopenia.

As far as the number of readings concerned the following numbers are generally agreed on most of the guidelines. The recommendation is to perform at least 21 readings in the daytime and 7 at night. In more than 70% readings capture success rate should be present.

- Minimum number is 2 per hour.
- Usually readings taken every 20 minutes in the day time and every 30 minutes at night.
- Check the diary to define day or night time excluding exercise and medication times

Some practical considerations while measuring the Ambulatory blood pressure include:

- The usage of the non-dominant arm unless the dominant arm has 10 mmHg or greater blood pressure compared to the non-dominant
- The patient has to keep a diary of events during the period of monitoring
- Settings to be adjusted to correspond to bedtime and time of awake period.
- The subject has to stop and stand still when a reading is being taken (if possible)

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