

# Ambulatory Blood Pressure Monitoring

A tool or a toy?

RORIVE Georges and KRZESINSKI Jean-Marie

Nephrology-Hypertension University Medical Center  
Sart Tilman – University of Liège- Liège 4000  
Tél. 04/366.72.03  
Fax. : 04/366.72.05  
Email : [georges.rorive@ulg.ac.be](mailto:georges.rorive@ulg.ac.be)  
[jm.krzesinski@chu.ulg.ac.be](mailto:jm.krzesinski@chu.ulg.ac.be)

From the very first determinations of blood pressure in his hare, S. Hales noticed that this parameter is highly variable and affected by muscular activity, pulse rate, respiration, pain and fear.

This observation was repeated by Riva Rocci, 100 years ago when he introduced the determination of blood pressure in clinical practice. In his original paper from December 18, 1896, he wrote : *"When the patient rests in the more comfortable position, usually, sat on his bed, complete rest and the greatest quietude are necessary, because any excitement, even the smalest, is a cause of significant modification of the blood pressure level"*.

During the first half of this century, the clinicians tried to answer to the variability of blood pressure level, by the determination of what was called "basal blood pressure". The measure was performed in conditions of physical as well as mental rest, sometimes with help of sedative drugs. This basal values were opposed to casual ones, obtained in the usual conditions of medical examinations.

However, most of our knowledge on hypertension as a cardiovascular risk factor has been written using casual blood pressure determination and sometimes very casual ones in epidemiological studies. For instance, the data from the life insurance companies correlating blood pressure with life expectancy or cardiovascular morbidity and mortality are based on a single determination of blood pressure.

If these data are of values in large population samples, they may be of limited signification to evaluate the vascular risk and the benefit that can be expected from antihypertensive therapy in individuals. Blood pressure measurements may indeed vary

between consecutive measurements over short period of time and particularly in the medical setting.

In 1969 Bevan et al. designed an device allowing the recording of blood pressure for long period of time through an intra-arterial catheter. Although this technology allowed to illustrate the variability as well as the nycthemeral rhythm of blood pressure, it must be accepted as a research tool and cannot be used in daily clinical practice.

Development of technology has allowed the availability of non invasive automated devices which not only measure blood pressure at different arterial sites for long period of time, but also allowed measurements to be stored. These devices introduced new parameters such as mean blood pressure levels on definite period of time (day, night, 24 hours), pressure load (period of time where blood pressure is over normal values), variability, nycthemeral rhythms,... in the evaluation of the hypertensive patients. Automated recording are also devoid of digit preference, observe bias and minimize the consultation effect.

Two different approaches are used to record blood pressure outside the doctor office : self measured home blood pressure and ambulatory automated recorders.

#### Ambulatory blood pressure recording

Many devices are presently available to record blood pressure outside the medical office, the patient is engaged in usual activities. Most of these devices have been submitted to the stringent criteria of the validation protocols of the *British Hypertension Society* (B.H.S.) and the *Association of the Advancement of the Medical Instrumentation* (AAMI).

The data have been published and are available in the scientific literature. See for instance O'Brien et al. (1993). Recently, the *British Hypertension Society* published additional data about the evaluation of these devices in specific conditions such as pregnancy, elderly and children.

These records provide between 50 to 100 determinations of blood pressure for a 24 hours period. They are the only one to provide data on blood pressure level during sleep. From these data mean blood pressure during 24 h period, during day activity period and during sleep may be calculated.

Pressure load blood pressure, variability as well as modifications in nycthemeral rhythm are also available. The use of ambulatory blood pressure recording for instance allowed the observation of a percentage of patients that do not experience the normal decrease of blood pressure during night time : the so called "no dippers subjects".

#### Relation between ABP and cardiovascular complications of hypertension

Several studies have shown that end organ damage associated with hypertension is more closely related to 24h ambulatory blood pressure than to office blood pressure. This has been established non only by cross sectional data but also a limited number of longitudinal studies (Cuspidi et al., 2000). Furthermore, recent longitudinal study has also demonstrated that treatment induced changes in 24h average blood pressure correlate with reduction in LVH, as well as the incidence of cardiovascular events, much more closely than to treatment induced changes in clinic BP (Mancia et al., 1997, Staessen et al., 1999).

Such a relation has also been reported with micro albuminuria and this is found in untreated as well as in hypertensive patients receiving treatment.

#### Absence of placebo effect

Several studies have clearly illustrated the good reproducibility from ambulatory blood pressure recording, with the exception of the first values in the first recording. This is, at variance, from office blood pressure, that is highly variable from one visit to another, and shows a significant and sometimes very impressive decrease with time.

On this aspect, ABP appears as a very useful tool for the evaluation of the efficacy of new antihypertensive agents. The good reproducibility of the measures and the absence of placebo effect increase the sensibility and allow significant comparative studies with a restricted number of subjects (Conway et al., 1988).

#### The dipping phenomenon

Usually, blood pressure significantly decreases during sleep. The importance of this decrease is correlated with the basal level of blood pressure. It is usually higher than 10 per cent. In a significant number of patients, such a phenomenon is not observed. Sometimes, blood pressure during night is even higher. This has been reported to be particularly frequent in secondary hypertension and in diabetes with nephropathy. It is however also observed in the general population. The frequency of this non dipping phenomenon differs highly from a study to another.

In our experience, taking a decrease of 10 per cent as limited, we observe such a non dipping in 20% of men and 12% of women in an unselected sample.

The difference between sexes is however not observed in other studies (Mancia et al., 1995, Staessen et al., 1995). It has been suggested that the absence of nocturnal dipping is more frequent in severe complicated hypertension. It is however unclear, whether the non dipping phenomenon is the cause as the result of the severity of the disease. (Verdecchia et al., 1990).

Using a large international database, Staessen et al. (1997) recently reported that the nocturnal fall showed a curvilinear relation with age. The smallest fall were observed in subjects older than 70 years. Moreover, the non dipping phenomenon is poorly reproducible and may be related to quality of sleep.

Analysing the ambulatory recording available in the Syst.Eur.Study, Staessen et al. (1999) observe a better correlation between ambulatory blood pressure and the incidence of cardiovascular end points, the relation being the highest with night blood pressure.

#### White coat hypertension

Very soon using ABP and later on self measurement of blood pressure, it appears that a significant percentage of patients with hypertensive values of blood pressure in the office setting have a normal blood pressure recorded at home, or event at work. This so called "*white coat hypertension*" or better "*isolated office hypertension*" have an estimated prevalence ranging from 12 to 53% dependant upon the population studied and the definition used for cut off values between normal and abnormal blood pressure levels. If the definition of elevated office blood pressure is usually accepted as higher than 140/90 mmHg, the definition of normal ambulatory blood pressure varies. Although, international consensus has recently be published. On the basis of the values accepted, marked

differences on the incidence and prognosis of the *white coat hypertension* are reported (Manning et al., 1999). Prevalence in patients with stage 1 borderline hypertension is not unsurprisingly found higher than in those with more severe hypertension. Its prevalence also increases with age and has been found as high as 40% by the age of 60. It is likely that patients with *white coat hypertension* have a lower incidence of target organ damage than hypertensive subjects. Controversy remains whether their cardiovascular risk is similar or greater than normotensive subjects.

Some studies indeed indicated that *white coat hypertension* is associated with a risk between normotension and hypertension.

The long term prognosis of *white coat hypertension* is unknown. But international guidelines recommend that these patients have a full assessment of cardiovascular risk. Subjects at high cardiovascular risk or with documented target organ should be considered for treatment. However, the *white coat hypertension* phenomenon is poorly affected by antihypertensive therapy and these patients may appear as resistant to treatment.

### The normal ABP values

#### Reference values

100 years after Riva Rocci, normal values for office blood pressure are still debated. The relation between blood pressure levels and cardiovascular risk is indeed a continuous one and no clear limit between safe and unsafe blood pressure can be identified. Normal values are thus mainly based on the benefit ratio of antihypertensive therapy, recently illustrated by the data from large epidemiological studies such as HOT.

It is thus not surprising that defining normal values for ambulatory blood pressure appears difficult. Two methodological approaches were used. First to statistically define which ambulatory values correspond to office blood pressure target level. 160/95 mmHg and 140/90 mmHg second to establish the ambulatory blood pressure levels in a sample of normotensive subjects.

The best method would be to analyse the relation between ambulatory blood pressure and cardiovascular morbidity and mortality. Such studies are presently running but data are not expected in a near future.

The table 1 provides the reference values presently proposed as normal and limit of hypertensive level. They show some variations from study to study. However in our area, 135/87 mmHg can be accepted as the upper limit of normal values for day time and 120/75 mmHg for night time. These values are significantly lower than office blood pressure.

Surprising enough, the values are the same for elderly than for middle age people and no differences were reported between men and women. This suggests that part of the age related changes in blood pressure might be due to a consultation effect.

#### Home blood pressure

Ambulatory Blood Pressure recording is however an expensive and somewhat compelling procedure. The availability of semiautomatic devices allowed the determination of blood pressure at home by the patient himself, in more comfortable conditions.

Rapidly this approach appears as providing many of the advantages of ABP at lower cost: good reproducibility, small placebo effect if any, better correlation with end organ damages than office blood pressure. Moreover, the recent expectation for information and education to the patients who are becoming active participants in their health care ... increases the interest for such a procedure.

It is however to be accepted that a large part of the recent interest of the population for the self determination of blood pressure is largely independent of medical influence, and supported by large commercial companies setting the automated devices. In this context the blood pressure measurements are almost never performed according to accepted protocols.

International guidelines for the use of this procedure have been recently published, stressing all together the basic methodology, the interest and the limitation of the method.

The devices available have also been validated by the *British Hypertension Society* and the *Association for the Advancement of Medical Instrumentation*.

Differences are much larger than for the material available for ambulatory blood pressure. Most of the devices produced and sold by appliance companies have not been submitted.

#### Reference values – diagnostic thresholds

Physicians have to well aware that the thresholds currently applicable for conventional office blood pressure cannot be extrapolated to the automated measurements, particularly when operated at home by the patient himself.

The same approaches have been used for self measurements, than for ambulatory blood pressure. It is statistical regression analysis of the relation between office blood pressure

and the patient finding. It is to calculate which home blood pressure corresponds to 140-90 mmHg in the office.

A second possible approach is based on the study of the relation between home blood pressure and the incidence of cardiovascular events. Since only limited data are available on this aspect, the reference values actually in use are provided by statistical analysis although admittedly, this has serious limitations (Table 2).

Until more data from prospective studies, 135/85 mmHg has to be considered as the upper limit of normality in the low risk subjects and 130/85 mmHg for patients such as diabetes or renal patients. The values proposed may also be used in elderly patients.

### User procedures

The recommendations for self measurements are the same as for office determination. The measurements should be taken with the patient seated and at rest for at least 5 minutes, avoiding smoking or coffee drinking, half an hour before determination. The device cuff should be placed at heart level and this is particularly of importance for the devices measuring blood pressure at the wrist level. The arm with the highest blood pressure level should be used.

The advantage of self measurements recording over office blood pressure is to allow the increase the number of determinations. One recent study concludes that two recording one at work and the other at home for 3 consecutive days are necessary to obtain reliable estimate of SBP and DBP.

The recent guidelines recommended at least duplicate measurements twice daily for three monitoring days. Clearly, the reduction of variability and the signification of the values obtained increase with the number of readings.

### Usefulness

As stated above, the main advantage of self measurements is increasing the number of values. It allows to predict the results of reported clinic measurements on a long period of time.

Self measurement has been shown not to be accompanied by a white coat effect, although the values obtained during the first time of use are frequently higher.

It has a very high specificity but a low sensitivity to detect hypertension as defined by ambulatory blood pressure. A negative results must be confirmed by ambulatory recording.

The prognostic significance of self measurements has only be evaluated by cross sectional studies. The blood pressure values recorded have shown a better correlation than office blood pressure with LVH, micro albuminuria, etc...

The Ohasama study reported a significant relation between survival and the highest quintiles of self measured blood pressure, but a J type curve between mortality and self measured DBP. The incidence of stroke is also better correlated with home blood pressure.

However studies are needed to compare the relative prognostic values of self to ambulatory blood pressure measurements.

Table 1. Mean and upper limit of normal ambulatory recording of blood pressure.

	Meta-analysis		International		Pamela		Belgian		Japanese	
			Guidelines		Study		Sample		Study	
	$\bar{m} + 2$ SD		$\bar{m} + 2$ SD		$\bar{m} + 2$ SD		$\bar{m} + 2$ SD		$\bar{m} + 2$ SD	
<b>Systolic BP</b>										
24 h 00	117	137	116	136	115	131	115	131	118	140
day time	122	106	122	143	120	137	122	139	121	144
night time	106	127	106	128	105	123	105	122	106	128
<b>Diastolic BP</b>										
24 h 00	72	87	70	84	72	84	70	82	69	83
day time	77	91	75	91	77	90	75	88	72	86
night time	64	79	78	76	63	77	60	72	61	75

(after MANCIA et al., 1995).

Table 2 : Reference values for self measurement of blood pressure

	SBP (mmHg)	DBP (mmHg)
Normal	115	71
95 <sup>th</sup> percentile	135	86
Hypertensive	137	85
OBP : 140/90	130	83

From Asmar and Zanchetti, 2000

## Conclusions

The determination of blood pressure either by ambulatory recording, either by self determination allow to increase the number of determination available. In that way, it make possible a more precise determination of true blood pressure level and by consequence the cardiovascular risk.

It has not been clearly established that the same result cannot be obtained by multiple determinations of office blood pressure on longer period of time.

Ambulatory recording as well as self determination show a better correlation with hypertension damages than office blood pressure and in that way a better definition of the population that will have significant benefit from antihypertensive therapy. The literature appears however some controversial. In one way, some specialists of hypertension claim that the abnormality is underdiagnosed and undertreated. On another way, one of the reasons justifying the introduction of ambulatory recording and self determination is the diagnosis of isolated office hypertension, and thus to identify a sample of the hypertensive subjects that do not need hypertensive therapy or at least will take a very small benefit of it.

The two methods have also the advantages to limit the placebo effect and thus to increase the sensitivity of blood pressure changes, particularly in clinical trials and evaluation of new drugs. In this use, the methods also allow to decrease the number of necessary subjects.

Ambulatory recording provides information about variability, nycthemeral rhythm and also to associated blood pressure levels with patients symptoms.

Self measurements increase the consciousness of the disease and might increase compliance. It might however increase anxiety. In our experience, many patients also take argument of blood pressure levels measured outside, the traditional rules to modify their treatment.

Both approaches have interest but their use must be well standardised and the meaning of the values recorded clearly explained to the patients.

## Advantages of ambulatory recording and self measurement of blood pressure

	ABP	Self measurement
Better definition of cardiovascular risk	+++	+++
Trials and new drugs evaluation	+++	+++
Though to peak determination	+++	±
Identification of white coat effect	+++	+
Symptomatic hypertension	+++	±
Resistant hypertension	+++	++
Teach the patient	0	±

## **Bibliography.**

1. Asmar, R. and A.Zanchetti. – Guidelines for the use of self blood pressure monitoring : a summary report of the first international conference.  
J.Hypertension, 2000 : 18; 493-508.
2. Imai, Y, A.Nishiyama, M.Sekino et al. – Characteristics of blood pressure measured at home in the morning and in the evening : the Ohasama study.  
J.Hypertension, 1999 : 17; 889-898.
3. Manning, G., L.Rushton and M.W.Millar-Craig. – Clinical implications of white coat hypertension : an ambulatory blood pressure monitoring study.  
J.Human Hypertension, 1999 : 13; 817-822.
4. Myers, M.G., B.Hagner and S.W.Rabkin. – Canadian Hypertension Society Guidelines for ambulatory Blood Pressure Monitoring.  
Am.J.Hypertension, 1999 : 12; 1149-1157.
5. O'Brien, E., N.Atkins and J.Staessen. – State of the market. A review of ambulatory blood pressure monitoring devices.  
Hypertension, 1995 : 26; 835-842.
6. Pickering, T.G. – Ambulatory monitoring and the definition of hypertension.  
J.of Hypertension 1992 : 10; 401-409.
7. Staessen J.A., L.Bieniaszewski, E.O'Brien et al. – Nocturnal Blood Pressure Fall in ambulatory monitoring in a large International Database.  
Hypertension 1997 : 29; 30-39.
8. Staessen, J.A., L.Thijs, R.Fagard et al. – Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension.  
JAMA 1999 : 282; 539-546.

9. Verdecchia P., C.Porcellati, C.Schillaci et al. – Ambulatory Blood Pressure :  
an independent predictor of prognosis in essential hypertension.  
Hypertension 1994 : 24; 793-801.