Ambulatory blood pressure monitoring

A pediatric review

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ABSTRACT

Hypertension is one of the major contributors to cardiovascular, renal and central nervous system morbidity and mortality. Although it is more prevalent in the adult population, hypertension and its sequelae are being seen in the pediatric population with increasing frequency. Blood pressure (BP) is not a static phenomenon. It is highly variable, changing constantly in response to various activities, stimuli, and stresses. Consideration of all of these factors make intermittent clinic BP measurements less effective in accounting for BP rhythmicity so ambulatory BP monitoring has emerged as a useful tool to give a detailed analysis of BP patterns during the day and night. It is becoming more and more evident that ABPM could be a useful tool in evaluation of white coat hypertension, apparent drug resistant hypertension, to evaluate efficacy of medications for control of hypertension, in evaluation of borderline hypertension, to further elaborate on chronology of hypertension and above all to assess the end organ damage risk as measurement of 24 hour BP parameters do correlate with hypertensive end organ injury.

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Hypertension is one of the major contributors to cardiovascular, renal and central nervous system morbidity and mortality. Although it is more prevalent in adult population, hypertension and its sequelae are being seen in the pediatric population with increasing frequency. The Second Task Force On Blood Pressure Control In Childhood of the A.A.P has recommended that all children ages 3 and above should have their blood pressure (BP) measured during health maintenance and emergent visits.[1] The current pediatric blood pressure norms are from a revision of the Task Force data from 1987 and from the more recent data from the National Health and Nutrition Examination Survey III, which screened 60,000 children from 1988 through to 1991.[2] Today we have the systolic and diastolic blood pressure normality tables for boys and girls age 1-17 years by percentiles of height.

Blood pressure is not a static phenomenon. It is highly variable, changing constantly in response to various activities, stimuli, and stresses. It also follows a diurnal pattern remaining on a plateau during the day, and falling approximately 10-25% during the evening to a nadir from midnight to 4 am known as nocturnal dipping. Then there is a substantial rise in BP upon awakening related to activity. Accompanying this are changes in heart rate, catecholamine levels, and glucocorticoid level. In addition, some patients have abnormally elevated blood pressure on casual measurements; a transient stress response called white coat hypertension.[3] This can result in over diagnosis and unnecessary diagnostic and therapeutic interventions. All of the above mentioned factors make intermittent clinic blood pressure measurements ineffective in accounting for BP rhythmicity so ambulatory blood pressure monitoring (ABPM) has emerged as a useful tool to give a detailed analysis of blood pressure patterns during the day and night.

Methods. Ambulatory blood pressure monitoring measures blood pressure several times during the day

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and night accurately reflecting continuous pattern of blood pressure in the individual's routine environment. A wide variety of devices are available for the measurement of ambulatory blood pressure.[4] Commonly used ones are those validated by either British Hypertension Society or American Association for the Advancement of Medical Instrumentation. The commonly used ABPM devices in pediatrics are Space lab 90207/90217 and Meditech ABPM 04. These monitors are small and lightweight, have appropriate size BP cuffs for use in children of all ages. The monitor is attached to the individual via an appropriate size cuff. Systolic and diastolic BP are measured on an average of every 20-30 minutes while awake and every 30-60 minutes while asleep. The individual is instructed to avoid vigorous motion while BP is being taken and to keep a diary of symptoms and timings of awakening and sleeping. Sleep/awake periods are either preset as 10 pm–6 am and 6 am-10 pm, or 8 pm-8 am and 8 am-8 pm. These could also be actual sleeping time and awake times as well.

Analysis of ambulatory blood pressure monitoring data. The data obtained by ABPM can be analyzed and assessed by a variety of methods. Most commonly used variables are 24 hour mean systolic BP, 24 hour mean diastolic BP, separate day and night time means, blood pressure load, BP index, Dipper's versus Non-Dippers, for example. Blood pressure load is defined as percentage of total blood pressure measurements exceeding upper limit of normal for age, sex, and height. It is generally accepted that BP load of 25% or more is considered as hypertension. It correlates nicely with end organ damage. A dipper is classified as someone who has a minimum of 10% fall in mean BP. Several other techniques like Cusinor Analysis, Forvier Analysis, Cusom Analysis, for example are used to analyze rhythmic data but they do not correlate with end organ damage and their details are beyond the scope of this article.

Clinical utility of ambulatory blood pressure monitoring. It is becoming quite evident that ABPM could be a useful tool in the evaluation and the management of childhood hypertension, in addition it can also be very useful in dosage adjustment for fine tuning the BP control. Another very beneficial use of ABPM is it's potential ability to predict hypertensive end organ injury. Before ABPM could be used for the diverse purposes, it is necessary to prove whether it is accurate and reliable like any other diagnostic tool. In a study to evaluate overall success and reproducibility of ABPM measurement Lurbe et al[5] analyzed the data obtained in 333 children (aged 3-18) showing overall success rate of 76+15%.This was supported by Khan et al[6] showing 83% overall successful recordings from 190 measurements in a large pediatric center. The reproducibility of ABPM was also evaluated showing that ABPM values are more reproducible especially for day and night systolic BP's than the conventional BP measurements. Once a method is reliable and reproducible, the only limitation in its use is the reference values. So far, the pediatric data for ABPM norms are lacking. The first large study carried out to establish some norms came out from Germany by Soergel et al,[7] who published data from 1141 children with body height from 115-185 cm. It was a multi-center study with common protocol. This study gave the references for 24 hours; awake and sleep period values from 10th-95th percentiles based on gender and height **(Table 1)**.

Table 1 - Mean ambulatory blood pressure values in healthy children.

Height (cm)	(n)	Percentile for 24 hour period 50th	95th	Daytime percentile* 50th	95th	Nightime percentile** 50th	95th
Boys							
120	(33)	105/65	113/72	112/73	123/85	95/55	104/63
130	(62)	105/65	117/75	113/73	125/85	96/55	107/65
140	(102)	107/65	121/77	114173	127/85	97/55	110/67
150	(108)	109/66	124/78	115/73	129/85	99/56	113/67
160	(115)	112/66	126/78	118/73	132/85	102/56	116/67
170	(83)	115/67	128/77	121/73	135/85	104/56	119/67
180	(69)	120/67	130/77	124/73	137/85	107/56	122/67
Girls							
120	(40)	103/65	113/73	111/72	120/84	96/55	107/66
130	(58)	105/66	117/75	112172	124/84	97/55	109/66
140	(70)	108/66	120/76	114/72	127/84	98/55	111/66
150	(111)	110/66	122/76	115/73	129/84	99/55	112/66
160	(156)	111/66	124/76	116/73	131/84	100/55	113/6
170	(109)	112/66	124/76	118/74	131/84	101/55	113/66
180	(25)	113/66	124/76	120/74	131/84	103/55	114/66

* - daytime: 8 am - 8 pm, ** nighttime: midnight to 6 am
*** reproduced from Soergel et al[7]

There are now 2 larger studies involving 1121 English[8] and 750 Spanish[9] healthy children adding to the reference values. Definitely more extensive data are required if we are going to use it for our clinical advantage. One interesting finding from these large studies is the fact that the systolic BP rises with increasing height but diastolic does not, which is in contrast to the Task Force data. One of the major advantages of ABPM is to evaluate the patients who have White Coat Hypertension (WCH). White coat hypertension can account for 45-62%[10] when either ABPM normative data or Task Force data were used as reference. It is evident that if only casual blood pressures (CBP) are used to diagnose hypertension, then there will be a lot of resources allocated to the evaluation of etiology of something that is not present in the first place. It is more effective to use ABPM after repeated CBP showing elevated BP prior to extensive work up. There is increasing evidence that abnormal ABPM correlates with hypertensive end organ damage in children. The 5 organ systems that may be affected are blood vessels, brain, eyes, kidney and heart. Daniel et al[11] reported in a study of children with renovascular hypertension that 85% had evidence of end organ injury, 66% had left ventricular hypertrophy (LVH), 60% had retinopathy and 11% had renal insufficiency. In another study by the same author,[12] with average BP>90th percentile showed 36% to have LVH, 49% had glomerular hyper-filteration and 50% had retinopathy. Ambulatory blood pressure monitoring appears to be more predictive of end organ damage than CBP.

There are few studies using ABPM to look at target organ damage. Sorof et al[13] conducted a study on 37 untreated patients with hypertension to evaluate whether ABPM variable correlates with left ventricular mass index (LVMI) and the presence of left ventricular hypertrophy (LVH). They showed a correlation between 24 hour systolic blood pressure (r=0.34, P=0.037), 24-hour systolic blood pressure load (r=0.38, P=0.020) but they did not correlate with age, weight, or CBP. They also showed that 47% patients in study had LVH with Systolic BP load >50%. Belsha et al[14,15] evaluated hypertensive end organ damage in a population of adolescents with normal BP and untreated borderline and mild essential hypertension using ABPM. They showed that nocturnal systolic BP correlated most closely to LVMI (r=0.91, P=0.001). Ambulatory blood pressure monitoring has been shown to be a useful tool in the screening for early complications in chronic diseases like diabetes and renal transplant population. Results from studies in diabetics have shown that early diabetic changes occur with higher than normal ABPM and impairment of nocturnal dipping. Young et al[16] reported that patients with poor glycemic control correlates with impairment of nocturnal dip in blood pressure and measures of diastolic dysfunction. Theochiari et al[17] from Greece reported that systolic and diastolic BP loads were 50% higher in diabetics compared to age and sex matched controls, suggesting that hemodynamic changes may appear earlier than thought so far in children with diabetes.

It is an established fact that almost 70-80% children have hypertension one year after renal transplant,[18] and 60% are on anti-hypertensive medications 5 years after transplantation.[19] In studies of ABPM in transplant recipients it is shown that prevalence of hypertension is 60-70% despite use of medication.[20]

In conclusion, ABPM is most useful in recognizing children with WCH even though the notion that it predisposes to sustained hypertension remains debated. Never the less WCH should not be left unnoticed at this juncture till it proves to be benign and attempts should be made to recognize and eliminate any other risk factors. In addition, ABPM is found to be more effective than conventional blood pressure measurements not only in selection of the patients for antihypertension therapy but also to asses the efficacy of non-pharmacologic and pharmacologic therapy. There are fascinating new data for ABPM in special patient groups like Diabetics, Chronic Dialysis patients and post renal transplant etc. which are helpful in fine tuning the therapeutic modalities and improving the long term outcome. The future direction should definitely be towards establishing the normative data of ABPM in a heterogenous population.

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