

Ambulatory Blood Pressure Monitoring in Children: A Safe and Effective Diagnostic and Screening Tool for the Diagnosis of Hypertension in Children

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INTRODUCTION

Hypertension is becoming an increasingly recognized health problem in children. The obesity epidemic has led to a greater frequency of hypertension diagnosis in children. In adults, hypertension is a leading cause of preventable death, heart attack, stroke, and kidney disease. For all patients, the goal of identifying and treating hypertension is to prevent end-organ damage and reduce mortality.

DEFINITION OF HYPERTENSION IN CHILDREN

The definition and classification of pediatric hypertension was put forth in The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents published in 2004.¹ Using demographic data from approximately 64,000 children including NHANES surveys from 1999–2000, definitions of pediatric hypertension and prehypertension were published for children ages 1-17 years, using height percentiles of 5th, 25th, 50th, 75th, 90th and 95th respectively. Hypertension in children is defined as average Systolic and/or Diastolic BP that is > 95th percentile for gender, age and height on > 3 occasions. Prehypertension in children is defined as average Systolic or Diastolic blood pressures that are > 90th percentile but < 95th percentile. The term White Coat Hypertension is used when a child has blood pressures that are > 95th percentile in the clinic or office but < 90th percentile when measured outside of a clinical setting. Ambulatory Blood Pressure Monitoring (ABPM) is usually required to make this diagnosis.

In addition to defining hypertension cut-offs, the Fourth Report also provided valuable guidelines for the measurement of blood pressure in the pediatric population (Tables 1 & 2).

AMBULATORY BLOOD PRESSURE MONITORING (ABPM)

Ambulatory Blood Pressure Monitoring (ABPM) refers to a non-invasive procedure in which a portable blood pressure device,

worn by a patient, periodically records BP over a specified period of time, usually 24 hours.¹ ABPM is an important tool in evaluating pediatric hypertension. The information obtained during an ABPM study offers a more detailed and nuanced profile of an individual's blood pressure than can be gathered from a series of clinic measurements. It allows for assessment of White Coat Hypertension. It measures the average systolic and diastolic blood pressure during both wakefulness and sleep. It measures the proportion of time that the systolic and diastolic blood pressure is abnormally high. The proportion of time above normal is referred to as the blood pressure load. Each of these components of blood pressure contributes to understanding the particular cardiovascular and renal risk of an individual patient. Among children and adults, abnormalities of ambulatory blood pressure predict the development of hypertensive end-organ damage, specifically left ventricular hypertrophy.² Among adults, ambulatory blood pressure predicts cardiovascular events better than clinic blood pressures.³

During an ABPM procedure the patient has a blood

Table 1. Measurement of BP in Children.

Children >3 years old who are seen in a medical setting should have their BP measured
The preferred method of BP measurement is auscultation
Correct measurement requires a cuff that is appropriate to the size of the child's upper arm
Elevated BP must be confirmed on repeated visits before characterizing a child as having hypertension
Measurements obtained by oscillometric devices that are greater than 90th percentile should be repeated by auscultation

Table 2. Conditions under which Children Under 3 Years Old Should Have BP Measured.

History of Prematurity, very low birth weight, or other neonatal complication requiring intensive care
Congenital heart disease (repaired or non-repaired)
Recurrent urinary tract infections, hematuria, or proteinuria
Known renal disease or urologic malformations
Family history of congenital renal disease
Solid-organ transplant
Malignancy or bone marrow transplant
Treatment with drugs known to raise BP
Other systemic illnesses associated with hypertension (neurofibromatosis, tuberous sclerosis, etc)
Evidence of elevated intracranial pressure

pressure cuff placed by a nephrology nurse who measures the arm circumference to determine appropriate cuff size. The patient wears the cuff and a small electronic device which can be worn on a belt or in a pocket. The device prompts the cuff to inflate every 20 minutes during the day and every 30 minutes at night to measure blood pressure and also records the blood pressure readings. Patients are advised to avoid heavy physical activity during the study, because this raises blood pressure and can therefore cloud interpretation of the results. The patient wears the monitor for 24 hours. The monitor is then returned to the nephrology clinic and the readings are downloaded for analysis. The nephrologist reviews these results with the patient and family during a clinic visit.

ABPM is the best way to distinguish true hypertension from white coat hypertension. White coat hypertension exists when the blood pressure is elevated in a medical setting, but normal when a patient is in their usual environment. Some case series indicate that 30% of children with elevated clinic blood pressure actually have white coat hypertension. It is imperative that these children understand their true cardiovascular risk, and that they be spared from unnecessary medical therapy. Children with white coat hypertension are also at increased risk for true hypertension and cardiovascular disease compared to their peers.⁴ For these children, ongoing blood pressure monitoring (sometimes with annual ABPM) may be necessary.

Blood pressure normally declines during sleep. This is referred to as the “nocturnal dip.” Blunted dipping is when the mean systolic or diastolic blood pressure declines by <10% during sleep. This occurs in association with renal disease, poor sleep quality, and the use of glucocorticoids. It is more common among African-Americans.³ Blunted dipping is commonly seen in patients with diabetes.² Adolescent diabetic patients with blunted dipping are more likely to develop microalbuminuria than adolescent diabetic patients with normal ABPM profiles.⁵ When blunted dipping is present, nocturnal administration of anti-hypertensive medication can restore a normal dip.

ABPM can be used to distinguish primary from secondary causes of hypertension in children. Awake diastolic blood pressure load >25% or asleep systolic blood pressure load >50% are both highly specific for diagnosing secondary hypertension in children.⁶ Children with secondary hypertension require a much more detailed evaluation to determine the cause of their blood pressure elevation than children with primary hypertension.

In the research setting, ABPM is frequently used to evaluate the effects of anti-hypertensive therapy. The use of ambulatory blood pressure (as opposed to casual blood pressure) offers to opportunity to evaluate duration of action of medications and assess patient compliance. It also allows measurement of changes in blood pressure variability and nocturnal dipping. Placebo medication has negligible effect on ambulatory blood pressure.³

The goal of all treatment of pediatric hypertension is to reduce cardiovascular risk. As such, accurate understanding of a child's blood pressure is especially important for those whose cardiovascular risk is already increased. Masked hypertension is the phenomenon of elevated ambulatory blood pressure when clinic blood pressure is normal. In the CKiD study, a cohort study of pediatric chronic kidney disease, children with masked hypertension had increased risk of left ventricular hypertrophy compared to those with normal ambulatory blood pressure.⁷ Children with diabetes, renal disease, dyslipidemia, or obesity are all at increased cardiovascular risk. Ambulatory blood pressure monitoring can be a useful tool in evaluating and screening for this risk.

PEDIATRIC HYPERTENSION AND ABPM PROGRAM AT HASBRO CHILDREN'S HOSPITAL

Pediatric Ambulatory Blood Pressure Monitoring has been available at the Pediatric Nephrology and Hypertension clinic at Hasbro Children's Hospital in Providence since 2007. Twenty-four hour ambulatory blood pressure measurement is performed using programmable portable oscillometric devices (Spacelabs Healthcare). The program is supported by a team comprising of pediatric nephrologists, a clinical nurse and a pediatric nutritionist. All children undergo ambulatory blood pressure monitoring for a 24-hour period. Patients also undergo screening with a random urine sodium to estimate their dietary salt intake as well a urinary microalbumin measurement to assess cardiovascular and endothelial injury risk. Demographic data including weight, height and BMI is obtained on all children. A detailed family, dietary and physical activity history is obtained to assess lifestyle risk and genetic risk factors. Children identified with metabolic syndrome and obesity are provided extensive nutritional and lifestyle counseling and undergo follow-up ABPM studies. Children fulfilling criteria for hypertension are evaluated for secondary causes of hypertension. Indications for drug therapy as recommended by the Fourth Report¹ are shown in **Table 3**.

As of June 2013, 606 successful ABPM studies have been performed at Hasbro Children's Hospital. Twenty-eight percent of children were found to be clinically hypertensive on ABPM study by definitions put forth by the Fourth Report.¹ Seven percent of children fulfilled criteria for prehypertension. Sixty-five percent of children had a normal 24-hour average blood pressure. Since the latter group was referred to the Pediatric Hypertension clinic on the basis of elevated

Table 3. Indications for Pharmacologic Therapy for Treatment of Hypertension.

Persistent hypertension despite non-pharmacologic measures
Symptomatic hypertension
Secondary hypertension
Evidence of hypertensive target organ damage
Diabetes (Type 1 and 2)

office blood pressures, these patients fulfill the diagnostic criteria for White Coat Hypertension. The fact that almost two-thirds of the children referred to our clinic for suspected hypertension turn out to have normal 24-hour ABPM studies (White Coat Hypertension) greatly underscores the importance of this modality as a screening and diagnostic tool.

The economic importance of using ABPM for the diagnosis of hypertension in children cannot be understated. Numerous studies have validated the primary use of ABPM for the diagnosis of hypertension in both children and adults as a cost-effective, safe and accurate tool.^{8,9} In addition, to providing cost savings, ABPM can avoid pain and anxiety in children from unnecessary and invasive tests ordered for work-up of hypertension. Judicious use of ABPM can reduce both physician and parental anxiety and increase productivity by reducing time lost from work and school. Standardized use of ABPM eliminates misdiagnosis of clinic hypertension from improper measurement technique, incorrect cuff size, patient anxiety and inter-observer variability since these are very common sources of erroneous blood pressure measurements in children.

CONCLUSION

Ambulatory blood pressure monitoring has been validated as a safe, painless, non-invasive and scientifically valid diagnostic and screening tool for the diagnosis of hypertension in both children and adults. Our experience indicates a high incidence of White Coat Hypertension in children referred for evaluation of suspected hypertension. When available, ABPM can provide significant economic benefit by reducing unnecessary workup as well as avoid patient and parental anxiety related to misdiagnosis of this important clinical condition. As the incidence of elevated blood pressure in children continues to rise, ABPM should be considered in all children at risk for developing hypertension so that appropriate preventive and therapeutic strategies can be implemented in early life to avoid long term morbidity and mortality related to this important clinical diagnosis.

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