Ambulatory Blood Pressure Monitoring in Children and Adolescents: 2022 Update: A Scientific Statement From the American Heart Association

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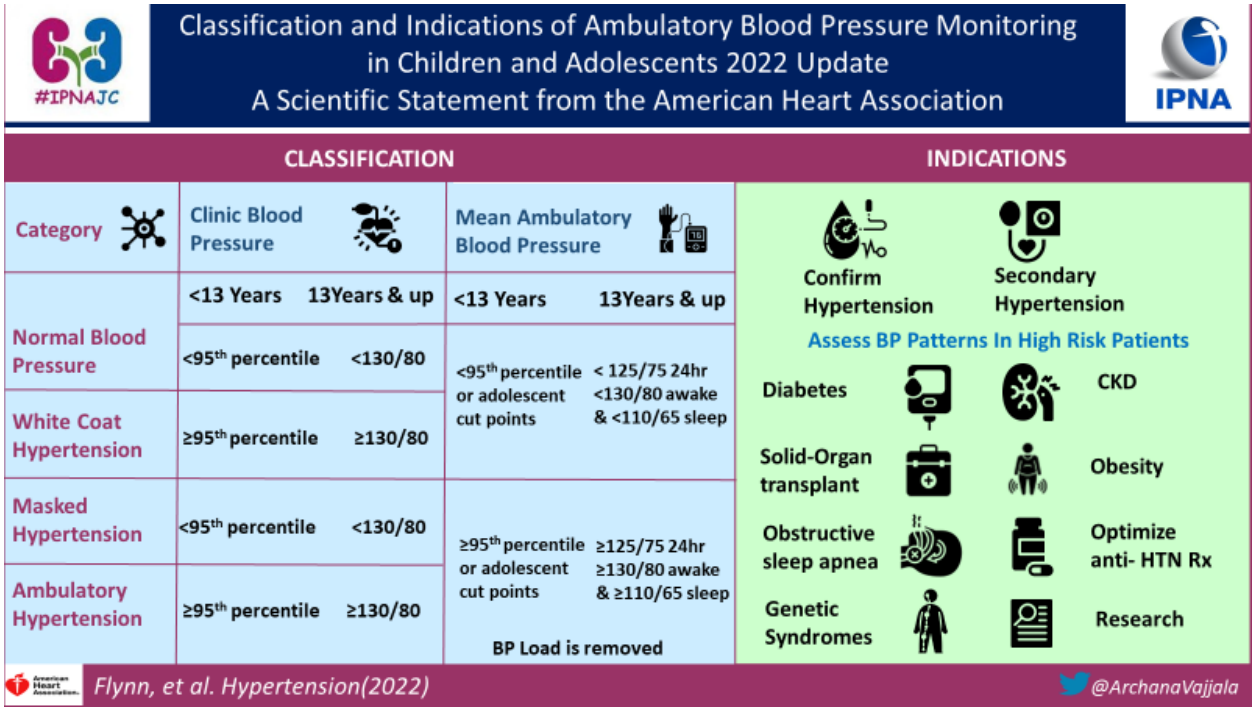

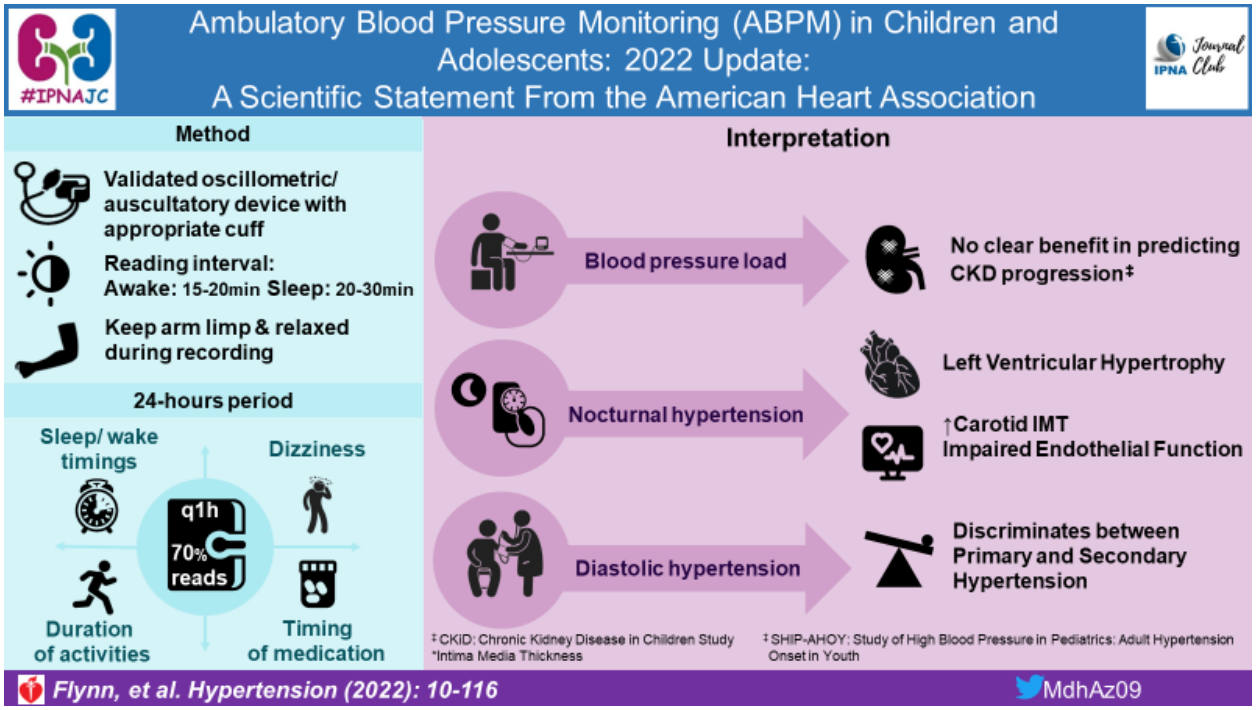

There is substantial data to suggest that higher blood pressure (BP) in youth is associated with target organ injury and increased risk for hypertension and cardiovascular disease in later adulthood. However, an accurate, evidence-based definition of hypertension in youth remains elusive. Ambulatory BP monitoring (ABPM) is an important test to aid in the diagnosis of youth-onset hypertension and may better predict target organ injury compared to clinic BP alone. The indications for ABPM as defined previously included:

- To ***confirm the diagnosis*** of hypertension in a patient found to have hypertension on the basis of clinic BP measurements
- Distinguish between ambulatory hypertension and ***white coat hypertension*** (WCH)
- To better assess BP in a patient with persistently in the ***elevated BP*** in clinic but not hypertensive range
- To evaluate for possible ***masked hypertension*** when there is a clinical suspicion of hypertension, but clinic BP readings are normal or in the elevated BP range
- To assess BP patterns in high-risk patients (Table 2):
    - Assess for *abnormal circadian variation in BP,* such as abnormal dipping, or isolated nocturnal hypertension in patients with diabetes, CKD, solid-organ transplant, and severe obesity with or without sleep-disordered breathing

    - Assess the *severity and persistence of BP elevation* in patients at high risk for hypertensive target organ injury
- To ***optimize drug therapy*** for hypertension:
    - Confirm BP control in treated patients
    - Evaluate for pseudo-resistant hypertension
    - Determine if symptoms suggestive of hypotension can be confirmed as such

However, pediatric ABPM guidelines continue to have significant weaknesses, including reliance on sex and age or height-based normative ABPM data to define high values at or above the 95th percentile, reliance on both mean ambulatory BP and load (i.e. the proportion of measurements ***at or above the 95th percentile***), and too many confusing classifications that can leave many patients unclassified. To address the above issues, the American Heart Association has issued an update on Ambulatory Blood Pressure Monitoring in Children and Adolescents in May 2022.

The new guideline provides three main updates:

(1) use ABPM to confirm the diagnosis of ambulatory hypertension prior to starting antihypertensive medication;

(2) provide additional resources for validated ABPM devices;

(3) provide a new classification schema (Table 1).

Table 1. Revised Classification for Ambulatory Blood Pressure Studies in Pediatric Patients

	Clinic systolic or diastolic blood pressure*		Mean ambulatory systolic or diastolic blood pressure	
Category	<13 y of age	≥13 y of age	<13 y of age	≥13 y of age
Normal blood pressure	<95th percentile	<130/80	<95th percentile OR adolescent cut points*	<125/75 mm Hg 24-h AND <130/80 mm Hg wake AND <110/65 mm Hg sleep
WCH	≥95th percentile	≥130/80		
Masked hypertension	<95th percentile	<130/80	≥95th percentile OR adolescent cut points*	≥125/75 mm Hg 24-h OR ≥130/80 mm Hg wake OR ≥110/65 mm Hg sleep
Ambulatory hypertension	≥95th percentile	≥130/80		

*Including 24 h, wake, and sleep blood pressure. WCH indicates white coat hypertension.

Table 2 Summary of clinical conditions where ABPM is recommended:

Table 2. Clinical Conditions and Other Settings Where Ambulatory Blood Pressure Monitoring Should Be Strongly Considered

Condition	Rationale for ambulatory blood pressure monitoring
Clinic hypertension	Confirmation of diagnosis
Secondary hypertension	Identify masked hypertension including nocturnal hypertension, abnormal dipping
Chronic kidney disease	Identify masked hypertension including nocturnal hypertension; assess mean arterial pressure and blood pressure targets to optimize therapy, slow disease progression, and reverse total organ damage
Coarctation of the aorta	Detect recurrent/masked hypertension years after primary repair
Types 1 and 2 diabetes	Identify abnormal circadian variation; optimize therapy to prevent/treat microalbuminuria and vascular changes
Obesity	Identify masked hypertension including nocturnal hypertension (which may signal comorbid obstructive sleep apnea) and abnormal dipping; optimize therapy to reverse total organ damage
Obstructive sleep apnea	Characterize hypertension severity, identify nocturnal hypertension or abnormal dipping
Genetic syndromes	Identify abnormal blood pressure patterns suggesting secondary cause of hypertension, such as renal artery stenosis and aortic coarctation
Neurofibromatosis type 1	
Turner syndrome	
Williams syndrome	
Antihypertensive drug treatment	Assess adequacy of blood pressure control and apparent treatment resistance, evaluate hypotensive symptoms
Research	Reduce sample size requirements for clinical trials; identify specific ambulatory blood pressure monitoring patterns associated with elevated cardiovascular risk

ABPM device prerequisites:

Device suitable for use in children should be selected:

- Only oscillometric or auscultatory ABPM devices validated as per American National Standards Institute (ANSI)/ Association for the Advancement of Medical Instrumentation (AAMI)/ International Organization for Standardization (ISO)

should be used. The British Hypertension Society standard acceptable for older devices
- Appropriate cuff sizes as recommended in the American Academy of Pediatrics 2017 Clinical Practice Guidelines should be used
- Use standard approach to obtaining ABPM studies
- Should be performed by trained personnel
- Place monitors in office setting to check for accuracy and for patient education
- Monitors to be applied to the *non-dominant arm* unless contraindicated
    - BP cuff to be placed on the arm with the higher BP if >5 mmHg difference in clinic BP between the 2 arms
    - In patients with repaired aortic coarctation with normal arch vessel anatomy, place the cuff on right arm
- Patients should record antihypertensive medication administration, physical exercise periods, unusual activity, and sleep and wake times in a diary
- After application, the ABP should be measured and compared with resting clinic BP using the same technique used by the ABPM device (auscultatory or oscillometric). If the average of 3 values is more than ±5 mmHg different, cuff placement should be adjusted, batteries changed, or the device's accuracy confirmed
- Devices should be programmed to record BP every *15 to 20 minutes during wake hours* and *every 20 to 30 minutes during sleep*

An optimal study meets the following criteria:

- Monitoring period spans 24 hours. Shorter periods of 18 to 20 hours acceptable if sleep period is captured and if all criteria are met
- At least ***70%*** of all attempted readings are successful
- Suboptimal studies can provide clinically useful information, but should be repeated
- Minimum of ***1 BP reading per hou***r, including during sleep
- ABPM recordings should be edited for outlying values
- Any resting BP measurements made with the ABPM device immediately after application of the device (e.g. test readings) should also be excluded
- Measurements during vigorous exercise should be excluded
- Standard calculations should be reported: Mean ambulatory systolic and diastolic BP during each of the 24-hour, wake, and sleep periods
- BP load (percentage of readings above the threshold value) is no longer used
- Extent of dipping (percent day-night difference) should be determined ([mean awake BP – mean sleep BP] / mean awake BP] * 100) for both systolic and diastolic BP

- Patient-recorded wake-sleep times from the diary should be used to denote the wake and sleep periods for analysis
- ABPM studies should be interpreted using appropriate pediatric normative data
    - ABPM values should be compared with sex and height or age-specific normative data obtained in large pediatric populations and not with clinic BP levels

Care of ABPM equipment includes yearly checks for accuracy; regular inspection of cuffs and tubing for defects, wear/tear, or air leaks; and cleaning the hardware with disinfecting wipes and laundering the reusable BP cuff cloth covers between patients. Before initiating ABPM, review patient's history for any contraindications such as latex allergy, clotting disorders, and significant nocturnal enuresis .

Serious adverse events related to ABPM have not been reported in children; however, recent data suggest poor tolerability in some adolescents. a cross-sectional study showed that poor tolerability to ABPM was associated with a higher prevalence of ambulatory hypertension.

Updated classifications

Most importantly, the updated ABPM guideline removes reliance on BP load to classify hypertension disorders and creates four classifications in line with adult and European guidelines: normal BP, WCH, masked hypertension, and ambulatory hypertension (Table 1).

<u>Load</u>

2014 AHA pediatric classification of ABPM included 2 additional BP stages: ambulatory prehypertension (mean BP <95th percentile, but BP load ≥25%) and severe ambulatory hypertension (mean BP ≥95th percentile and BP load >50%). Using 2014 AHA categories led to some patients being unclassified if they had elevated BP load but normal mean BP and clinic BP that was either normal (<90th percentile) or hypertensive (≥95th percentile). In addition, the role of prehypertension in predicting clinical outcomes or subclinical target organ injury was unclear. The utility of isolated increased BP load in predicting hypertensive target organ injury in children was assessed recently in children with chronic kidney disease and in otherwise healthy children without hypertension. Load was therefore removed from the 2022 pediatric ABPM guidelines based on data from the CKiD and SHIP-AHOY studies that showed no clear benefit of using load in addition to mean BP in predicting progression of chronic kidney disease or left ventricular hypertrophy in children with chronic kidney disease stages II–IV.

<u>Single BP cut point</u>

The 2014 AHA definition of ambulatory hypertension was based on the sex and height or age-specific 95th percentiles and BP load for all ages without consideration of adult cut points. In tall and older adolescents, particularly boys, the 95th percentile values are often higher than either European Society of Hypertension (mean wake BP 135/85 mmHg, mean sleep BP 120/70 mmHg, and mean 24-hour BP 130/80 mmHg) or ACC/AHA adult cutoffs (mean wake BP 130/80 mmHg, mean sleep BP 110/65 mmHg, and mean 24-hour BP 125/75 mmHg). Recent analyses demonstrated that the use of adult absolute ABPM values to define ambulatory hypertension was comparable to sex and height-based 95th percentiles in predicting left ventricular hypertrophy in adolescents ≥13 years of age. Thus, the new 2022 guideline classifies BP based on absolute values in adolescents ≥13 years of age and, in children <13 years of age, the lower of either the 95th percentile or the adolescent cutoff.

Confirmations

Diastolic hypertension

The 2014 AHA guidelines recognized that some patients, especially those with secondary hypertension, could have isolated diastolic hypertension on ABPM. Since then, it has been shown in various studies that ambulatory diastolic hypertension may discriminate between primary and secondary hypertension. Some discrepancy is expected in diastolic BP measurement by ABPM, primarily because most ABPM devices used in pediatrics measure BP by the oscillometric technique, which has been shown to be less accurate for diastolic than systolic BP in validation studies. In addition, the widely used normative data for pediatric ABPM lacks variability for diastolic BP with age and height probably due to the use of the oscillometric technique. However, the awake 95th percentile diastolic BP values found in the ***Wühl pediatric ABPM normative data are high (82–84 mmHg and similar for boys and girls and regardless of height)***, so sustained diastolic BP levels above this value should be considered hypertensive. Thus, diastolic BP is recommended to continue to be used as part of the interpretation of ABPM studies.

Nocturnal hypertension

The 2014 AHA guidelines recommended that patients can be considered to have ambulatory hypertension solely on the basis of high nocturnal BP. Evidence for this has increased slightly in recent times including the high prevalence of isolated nocturnal hypertension in solid organ transplant recipients, in patients with obstructive sleep apnea, in children and adolescents with obesity, and patients with chronic kidney disease. Nocturnal hypertension has been associated with target organ injury such as left ventricular hypertrophy and increased carotid intima-media thickness in patients with chronic kidney disease and diabetes, and abnormal nocturnal BP dipping has been

associated with impaired endothelial function in hematopoietic stem cell transplant recipients. Therefore, in the 2022 guidelines, nocturnal hypertension should continue to be used as part of the interpretation of ABPM.

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