# Comparison of Pediatric and Adult Ambulatory Blood Pressure Monitoring Criteria for the Diagnosis of Hypertension and Detection of Left Ventricular Hypertrophy in Adolescents

Kumail Merchant, MD[1], Paras P. Shah, BA[1,2], Pamela Singer, MD[1], Laura Castellanos, MD[1], and Christine B. Sethna, MD, EdM[1,2]

**Objective** To compare pediatric ambulatory blood pressure monitoring (ABPM) criteria with adult ABPM criteria for the diagnosis of hypertension and detection of left ventricular hypertrophy (LVH) in adolescents.

**Study design** ABPM and echocardiography reports from adolescents age 13-21 years from 2015 to 2019 were analyzed. The concordance of hypertension based on pediatric criteria (American Heart Association 2014) was compared with adult criteria from American College of Cardiology/American Heart Association 2017 (overall BP ≥125/75 mm Hg, wake BP ≥130/80 mm Hg, sleep BP ≥110/65 mm Hg) using the Cohen kappa statistic. Logistic regression, adjusted for body mass index z score, and receiver operating characteristic curves (ROCs) compared pediatric criteria vs adult criteria in predicting LVH (left ventricular mass index >95th percentile reference values and left ventricular mass index >51 g/m$^{2.7}$).

**Results** Of 306 adolescents, 140 (45.8%) had hypertension based on pediatric criteria vs 228 (74.5%) based on adult criteria; the agreement was poor (59.3%, n = 137, kappa = 0.41). A higher prevalence of LVH was captured by adult criteria only (n = 91) compared with pediatric criteria only (n = 3). Logistic regression found no significant differences between pediatric and adult criteria in the detection of LVH >95th percentile (OR 1.24, CI 0.66, 2.31, $P$ = .51) or >51 g/m$^{2.7}$ (OR 1.06, CI 0.47, 2.40, $P$ = .89). ROCs for pediatric criteria were not significant for detecting LVH >95th percentile (0.50, $P$ = .91) or >51 g/m$^{2.7}$ (0.55, $P$ = .45), whereas the ROC for adult criteria was significant for detecting LVH >95th percentile (0.59, $P$ = .045) but not >51 g/m$^{2.7}$ (0.63, $P$ = .07). Although all individuals with LVH >51 g/m$^{2.7}$ were hypertensive by adult criteria, 8 of these individuals were missed by pediatric criteria.

**Conclusions** Adult criteria captured a higher prevalence of LVH and appeared to predict better LVH than pediatric criteria. A consideration to align ABPM criteria for diagnosing hypertension in adolescents with adult guidelines is warranted. *(J Pediatr 2021;230:161-6)*.

Ambulatory blood pressure monitoring (ABPM) has been proposed as a more accurate metric of whether a child's office blood pressure (BP) warrants further evaluation.[1]

The American College of Cardiology (ACC) and American Heart Association (AHA) 2017 clinical practice guidelines redefined hypertension in adults as office systolic BP (SBP) ≥130 mm Hg or diastolic BP (DBP) ≥80 mm Hg averaged on 2 or more readings on 2 or more separate occasions.[2] In the pediatric population, the threshold values for office BP measurements in adolescents ≥13 years were updated in 2017 to align with adult guidelines to better identify children at risk for hypertension and negative cardiovascular outcomes.[3]

The United States Preventive Services Task Force recommends utilization of ABPM as a reference standard in the diagnosis of hypertension in adults.[4] Similarly, the ACC and AHA 2017 guidelines recommend the use of daytime ABPM or home BP monitoring to confirm the diagnosis of adult hypertension. ABPM measurements above the thresholds for overall BP ≥125/75 mm Hg, wake BP ≥130/80 mm Hg, and sleep BP ≥110/65 mm Hg (comparable with clinic BP measurement ≥130/80 mm Hg) are associated with increased morbidity and mortality.[5] In comparison, because of a lack of outcome data in children, the most widely accepted pediatric ABPM values are derived from a population of 1141 healthy white Central European children first

| | |
|---|---|
| ABPM | Ambulatory blood pressure monitoring |
| ACC | American College of Cardiology |
| AHA | American Heart Association |
| BMI | Body mass index |
| BP | Blood pressure |
| DBP | Diastolic BP |
| LVH | Left ventricular hypertrophy |
| LVMI | Left ventricular mass index |
| ROC | Receiver operating characteristic curve |
| SBP | Systolic BP |

From the [1]Cohen Children's Medical Center of New York, New Hyde Park, NY; and the [2]Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, NY

The authors declare no conflicts of interest.

0022-3476/$ - see front matter. 
https://doi.org/10.1016/j.jpeds.2020.11.003

published in 1997.[6] In 2002, these normative values were smoothed for age and height by the modified lambda-mu-sigma method, resulting in the normative values most widely used today.[7]

There are some discrepancies in the threshold cut-offs when comparing the most recent adult and pediatric ABPM guidelines for the diagnosis of hypertension. For example, whereas the adult guidelines utilize a mean wake SBP ≥130 mm Hg or mean wake DBP ≥80 mm Hg, the current pediatric threshold of >95th percentile for mean wake SBP is higher than the adult threshold for boys 160 cm and taller (132.3-143 mm Hg) and the mean wake DBP is higher than the adult threshold for boys and girls 120 cm and taller (81.2-84.1 mm Hg). Likewise, the adult guidelines utilize a mean sleep SBP value of ≥110 mm Hg, but pediatric threshold of >95th percentile is higher for boys and girls 135 cm and taller (111.3-123 mm Hg). There are no pediatric ABPM reference data for children under 120 cm in height. Pediatric ABPM guidelines currently utilize BP loads (percentage of BP readings that exceed the 95th percentile threshold) in defining hypertension, whereas the most recent adult guidelines do not as they have not been found to add additional prognostic information beyond SBP and DBP.[8] In interpreting pediatric ABPM data, BP loads >25% are considered elevated and are associated with left ventricular hypertrophy (LVH) (especially SBP loads), which is associated with increased cardiovascular morbidity and mortality.[9]

The purpose of this study was to compare pediatric vs adult ABPM criteria for the diagnosis of hypertension in adolescents. We also sought to determine which criteria had stronger predictive ability to identify individuals who are hypertensive with LVH on echocardiography.

## Methods

Adolescents 13-21 years of age from a single center in New York (Cohen Children's Medical Center of Northwell Health) who had an ABPM performed between 2015 and 2019 were included in this retrospective study. A total of 414 ABPM studies were performed in this population during this time period. ABPM data were only included if the report had at least 40 total BP readings, at least 1 BP measurement each hour, and at least 65% of BP readings were successful.[10] Of the 414 ABPM results collected, 306 met these inclusion criteria. No exclusion was performed based on previous diagnosis of hypertension, severity of hypertension, chronic kidney disease status, transplant status, or indication for ABPM (screening vs monitoring). The study was approved by the Institutional Review Board of Northwell Health.

Participant demographic information (age, sex, height, weight) was obtained from the electronic medical record. Body mass index (BMI) was calculated by height and weight and converted to z-scores.

Spacelabs ABPM devices (model 90217A; Spacelabs Healthcare) were utilized in this study. Participants were instructed to wear the monitor on their nondominant arm for 24 hours, including overnight. Nighttime readings were determined by self-reported sleep and wake times. ABPM data were analyzed via Spacelabs software.

ABPM reports of each participant were interpreted by 2 sets of criteria. Pediatric ABPM hypertension criteria were based on the 2014 AHA guidelines, utilizing normative reference data from Wuhl et al.[7] The diagnosis of hypertension was made by mean ambulatory overall, wake, or sleep SBP or DBP >95th percentile with a concurrent SBP or DBP load ≥25%.[10] Adult ABPM hypertension criteria were derived from the most recent adult hypertension guidelines from the ACC and AHA. These guidelines diagnose hypertension if any of the following criteria are met by ABPM: overall mean SBP ≥125 mm Hg, overall mean DBP ≥75 mm Hg, mean wake SBP ≥130 mm Hg, mean wake DBP ≥80 mm Hg, mean sleep SBP ≥110 mm Hg, or mean sleep DBP ≥65 mm Hg.[2] It is important to note that because these 2 criteria are not mutually exclusive, individuals can be diagnosed by pediatric criteria only, adult criteria only, or both.

Echocardiography reports were obtained from the medical record. Studies were performed by technicians according to the most recent American Society of Echocardiology guidelines and studies were interpreted by one of the pediatric cardiologists at the study institution.[11] Left ventricular mass index (LVMI) was calculated for each echocardiogram utilizing M-mode measurements for interventricular septum, left ventricular internal diameter, and left ventricular posterior wall and the Devereux formula for left ventricular mass indexed to height$^{2.7}$.[12,13] Only echocardiography studies performed within 6 months of the date the ABPM was performed were included. Of the 306 adolescents with ABPM data, echocardiography data were available for 161 adolescents (52.6%). LVH was defined as LVMI >95th percentile for age and sex by reference values[14] as well as LVMI >51 g/m$^{2.7}$.[15]

Demographic and clinical characteristics were expressed as means with SDs and as proportions. The prevalence of hypertension based upon pediatric or adult criteria was expressed as proportions. Concordance of the 2 diagnostic criteria was evaluated utilizing the Cohen kappa coefficient statistic.

Receiver operating characteristic curves (ROCs) with area under the ROC were utilized in comparing individuals who were hypertensive by pediatric vs adult criteria in detecting the presence of LVH. Logistic and linear regressions, adjusted for BMI z score, were utilized to determine if significant differences existed in diagnosing LVH and LVMI, respectively, between adolescents who met hypertension based on pediatric criteria vs adult criteria. Two-sided $P$ value of ≤.05 was considered statistically significant for all analyses. SPSS v25 (IBM Inc) and STATA 16 (StataCorp LLC) statistical packages were used.

## Results

A total of 306 adolescents met eligibility criteria with acceptable ABPM data available. When comparing the

**Table I. Demographic information**

| Variables | Total n = 306 Mean (SD) or n (%) | Diagnostic ABPM criteria: Pediatric criteria n = 140 (45.8%) | Diagnostic ABPM criteria: Adult criteria n = 228 (74.5%) | *P* value |
|---|---|---|---|---|
| Age | 15.92 (1.86) | 16.06 (1.93) | 15.90 (1.86) | .45 |
| Male | 225 (75%) | 86 (61%) | 165 (72%) | .03 |
| BMI | 26.38 (6.45) | 25.95 (7.11) | 26.25 (6.48) | .67 |
| BMI z score | 1.07 (1.16) | 0.90 (1.16) | 1.05 (1.09) | .22 |
| mSBP | 123.05 (10.00) | 128.86 (9.63) | 126.39 (8.81) | .01 |
| mDBP | 69.68 (8.22) | 73.92 (8.90) | 71.29 (8.54) | .01 |
| mSBP load | 28.40 (25.42) | 46.34 (25.69) | 35.14 (25.44) | <.001 |
| mDBP load | 22.61 (21.65) | 34.78 (24.92) | 26.88 (22.90) | .002 |
| wSBP | 126.03 (10.56) | 131.06 (10.54) | 129.00 (9.70) | .06 |
| wDBP | 72.35 (8.94) | 76.05 (9.95) | 73.73 (9.35) | .03 |
| wSBP load | 25.66 (26.59) | 41.60 (29.41) | 31.01 (27.69) | <.001 |
| wDBP load | 21.77 (23.00) | 32.85 (27.22) | 25.61 (24.48) | .01 |
| sSBP | 114.65 (16.44) | 123.98 (10.97) | 120.14 (10.18) | <.001 |
| sDBP | 62.18 (10.93) | 68.59 (9.34) | 65.00 (9.06) | <.001 |
| sSBP load | 38.18 (33.46) | 63.91 (30.27) | 48.58 (31.85) | .01 |
| sDBP load | 33.77 (28.73) | 51.78 (30.73) | 40.03 (29.73) | <.001 |

*mDBP*, mean DBP; *mSBP*, mean SBP; *sDBP*, mean sleep DBP; *sSBP*, mean sleep SBP; *sDBP*, mean sleep DBP; *wDBP*, mean wake DBP; *wSBP*, mean wake SBP.

**Table II. LVH by hypertension criteria**

| | Hypertension | LVMI >95th percentile (n = LVH/ echocardiography*) | LVMI >51 g/m$^{2.7}$ (n = LVH/ echocardiography*) |
|---|---|---|---|
| Pediatric criteria† | 140 (45.8%) | 34/78 (43.6%) | 11/78 (14.1%) |
| Adult criteria‡ | 228 (74.5%) | 62/124 (50.0%) | 19/124 (15.3%) |
| Pediatric criteria and adult criteria§ | 137 (44.8%) | 34/76 (44.7%) | 11/76 (14.5%) |
| Pediatric criteria only¶ | 3 (1.0%) | 0/2 (0%) | 0/2 (0%) |
| Missed by pediatric criteria | - | 37/83 (44.6%) | 8/83 (9.6%) |
| Adult criteria only** | 91 (29.7%) | 28/48 (58.3%) | 8/48 (16.7%) |
| Missed by adult criteria | - | 9/37 (24.3%) | 0/37 (0%) |
| Pediatric criteria sensitivity | - | 47.9% | 57.9% |
| Pediatric criteria specificity | - | 51.1% | 52.8% |
| Adult criteria sensitivity | - | 87.3% | 100% |
| Adult criteria specificity | - | 31.1% | 26.1% |

*Individuals with LVH divided by number of available echocardiography studies.
†Individuals diagnosed with hypertension based on pediatric hypertension guidelines, from AHA 2014.
‡Individuals diagnosed with hypertension based on adult hypertension guidelines from ACC/AHA 2017.
§Individuals diagnosed with hypertension by both criteria.
¶Individuals diagnosed with hypertension by pediatric hypertension criteria but further eliminating those diagnosed by both criteria.
**Individuals diagnosed with hypertension by adult hypertension criteria but further eliminating those diagnosed by both criteria.

**Table III. Echocardiography information**

| | Total Mean (SD) or n (%) n = 161 | Diagnostic ABPM criteria: Pediatric criteria n = 78 | Diagnostic ABPM criteria: Adult criteria n = 124 | *P* value |
|---|---|---|---|---|
| LVMI | 39.27 (10.49) | 39.99 (11.88) | 40.61 (11.25) | .71 |
| LVMI >95th percentile | 71 (44.10) | 34 (43.59) | 62 (50.00) | .37 |
| LVMI >51 g/m$^{2.7}$ | 19 (11.80) | 11 (14.10) | 19 (15.32) | .81 |

demographics of those who had hypertension based on pediatric vs adult criteria, there were no significant differences in age, BMI, BMI z-score, or mean wake SBP (Table I). However, all other variables, including sex, mean SBP, mean DBP, and all load measurements were significantly different between the 2 groups. Overall, 140 adolescents (45.8%) had hypertension based on pediatric criteria compared with 228 (74.5%) based on adult criteria. There was 59.3% agreement (n = 137) in the diagnosis of hypertension between pediatric criteria and adult criteria (Cohen kappa coefficient = 0.41). Three participants (1.0%) had hypertension by pediatric criteria only, and 91 participants (29.7%) had hypertension by adult criteria only (Table II).

Table III shows the prevalence of LVH in our study, stratified by diagnostic criteria. Of those with LVMI >95th percentile, 34 (47.9%) met pediatric criteria while 62 (87.3%) met adult criteria ($P$ = .37). Of those with LVMI >51 g/m$^{2.7}$, 11 (57.9%) met pediatric criteria and 19 (100%) met adult criteria ($P$ = .81). There was no significant difference in LVMI between individuals diagnosed with hypertension by pediatric criteria vs adult criteria ($P$ = .71). The sensitivities of pediatric criteria and adult criteria in detecting LVMI >95th percentile were 47.9% and 87.3%, respectively, whereas the specificities were 51.1% and 31.1%, respectively. The sensitivities of pediatric criteria and adult criteria in detecting LVMI >51 g/m$^{2.7}$ were 57.9% and 100%, respectively, whereas the specificities were 52.8% and 26.1%, respectively (Table II). Although adult criteria captured a greater proportion of LVH when compared with pediatric criteria, 9 (5.6%) adolescents who had LVH >95th percentile did not have hypertension by either criteria. Five of these 9 individuals were previously diagnosed with hypertension and were on antihypertensive therapy at the time of ABPM and echocardiography. The remaining 4 individuals had no history of hypertension but had a BMI >95th percentile. Only 3 (1.0%) adolescents had hypertension by pediatric criteria only, and of these none with echocardiography performed had LVMI >95th percentile or LVMI >51 g/m$^{2.7}$.

In ROC analysis for detecting LVMI >95th percentile, the area under ROC for adult criteria was 0.59 ($P$ = .045) compared with 0.50 ($P$ = .91) for pediatric criteria. In detecting LVMI >51 g/m$^{2.7}$, the area under ROC was 0.63 ($P$ = .07) for adult criteria compared with 0.55 ($P$ = .45) for pediatric criteria (Figure). The difference in area under ROC

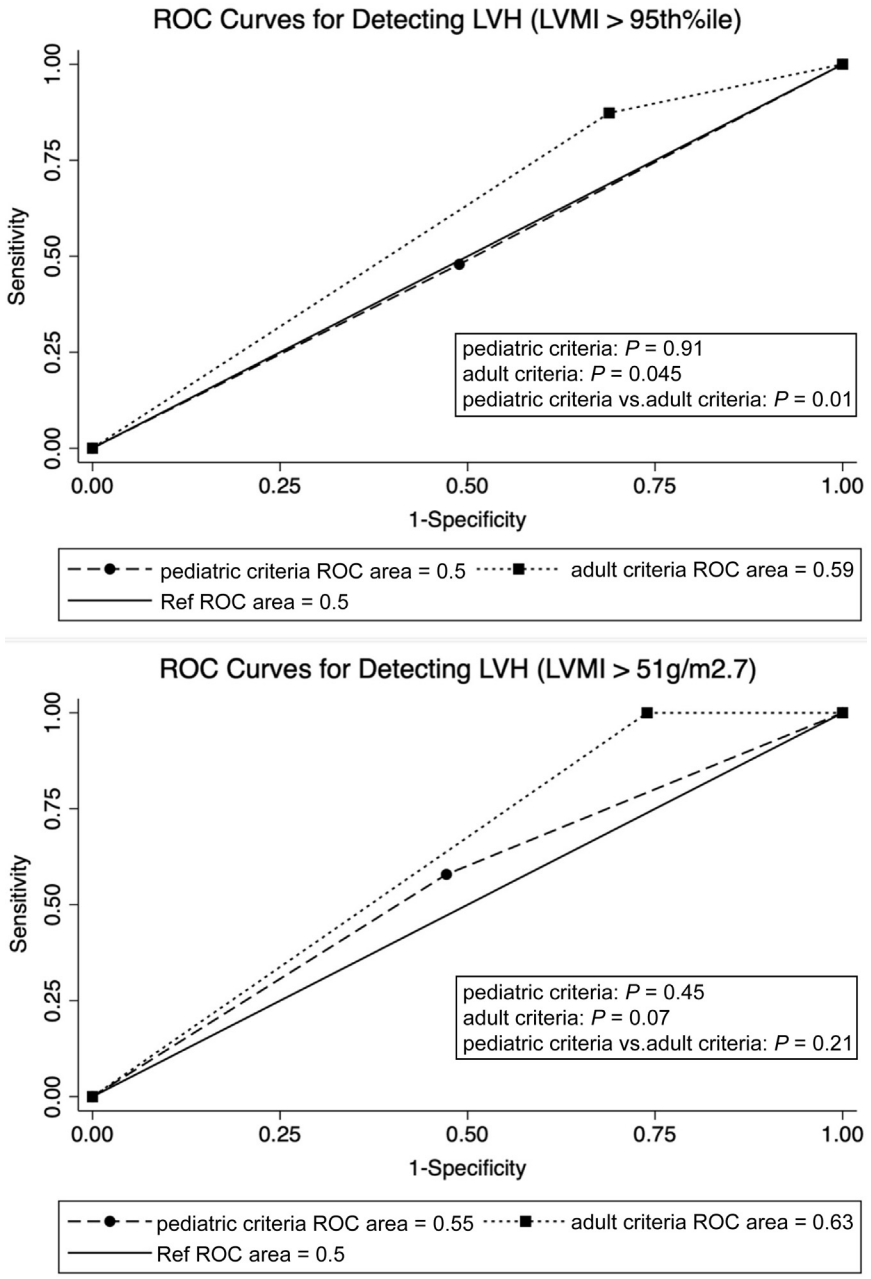


**Figure.** ROC analyses for detecting LVH >95th percentile were significant for adult criteria (0.59, $P = .045$) but not for pediatric criteria (0.50, $P = .91$). ROC analyses for detecting LVH >51 g/m$^{2.7}$ were not significant for adult criteria (0.63, $P = .07$) or pediatric criteria (0.55, $P = .45$).

between the 2 criteria was significant for LVMI >95th percentile ($P = .01$) but not for LVMI >51 g/m$^{2.7}$ ($P = .21$).

In logistic regression, there were no significant differences between pediatric criteria and adult criteria in the detection of LVH by LVMI >95th percentile in unadjusted (OR 1.3, 95% CI 0.68, 2.35, $P = .46$) or adjusted models (OR 1.24, 95% CI 0.61, 2.52, $P = .55$). There were also no significant differences between pediatric criteria (ref) and adult criteria in the detection of LVH by LVMI >51 g/m$^{2.7}$ in unadjusted (OR 1.1, 95% CI 0.47, 2.7, $P = .78$) or adjusted models (OR 1.1, 95% CI 0.46, 2.66, $P = .83$). Similarly, unadjusted ($\beta$ 0.6, CI -2.74, 4.46, $P = .64$) and adjusted ($\beta$ 0.41, 95% CI -2.81, 3.63, $P = .80$) linear regression models found no significant difference between pediatric criteria (ref) and adult criteria in LVMI values.

## Discussion

The findings of the current study revealed a poor concordance between pediatric criteria and adult criteria in the

diagnosis of hypertension, with a higher prevalence of adolescents being diagnosed with hypertension by adult criteria. Similarly, a higher prevalence of LVH (both LVMI >95th percentile and >51 g/m$^{2.7}$) was diagnosed with adult criteria. This was an expected finding given that some of the pediatric criteria threshold values for the diagnosis of hypertension are higher than those used by adult criteria. In addition, the inclusion of load within pediatric criteria makes it more selective in the diagnosis of hypertension as compared with adult criteria.

Ultimately, the goal of diagnosing pediatric hypertension is to identify patients at risk for cardiovascular morbidity and mortality. In 2017, the changes that lowered diagnostic thresholds for diagnosis of hypertension in adults were instituted to detect those at risk of negative outcomes as early as possible.[16] The changes that aligned adolescent guidelines for office BP measurements with adult absolute thresholds for elevated BP and hypertension were also recommended based on the predictive nature of these values for cardiovascular outcomes in adulthood.[17] This has become a particularly important issue in the adolescent population, as obesity, metabolic syndrome, dyslipidemia, and diabetes are increasing; these risk factors further increase morbidity and mortality with poorer outcomes as adults.[18] Therefore, the ideal pediatric hypertension criteria will detect the most at-risk individuals.

The ROC area was significantly higher for adult criteria compared with pediatric criteria for predicting LVMI >95th percentile, though there was no difference between the criteria for predicting LVMI >51 g/m$^{2.7}$. This may suggest adult criteria to be a better predictor of LVH than pediatric criteria. However, it is important to note that the areas under ROC were close to 0.5 for both pediatric criteria (0.50) and adult criteria (0.59), bringing into question the strength of their discriminatory ability regarding LVH. In addition, there was no difference between pediatric criteria and adult criteria in the detection of LVH by logistic or linear regression. Although there were 9 individuals with LVMI >95th percentile who did not meet either diagnostic criteria for hypertension, 5 had previously been diagnosed with hypertension and were already on antihypertensive therapy at the time of the ABPM. It is likely that although these individuals had well controlled BPs on their current antihypertensive regimen, their left ventricular changes had yet to improve. The other 4 individuals were not found to have hypertension but did have a LVMI >95th percentile on initial echocardiography. These individuals had echocardiography performed despite not being found hypertensive by ABPM criteria because they were referred to cardiology where echocardiography was done prior to nephrology evaluation and ABPM being performed. It is important to note that all 4 of these individuals had a BMI >95th percentile, which is a risk factor for LVH, though none had a LVMI >51 g/m$^{2.7}$.

LVH is utilized in the pediatric population as a marker of hypertensive end organ cardiac damage.[19] ABPM is, therefore, used as a cost-effective diagnostic tool for differentiating true elevated BP or hypertension from white coat hypertension, and guides which patients should have further evaluation, such as echocardiography.[20] It is estimated that 10% to 15% of pediatric patients with hypertension have severe LVH (LVMI >51 g/m$^{2.7}$), although the true prevalence in patients who do not meet hypertension criteria is unknown. Severe LVH further increases the risk of negative outcomes in these children when they reach adulthood, such as myocardial infarction and stroke.[21] Our findings suggest that adult criteria is far more sensitive in detecting both LVMI >95th percentile and LVMI >51 g/m$^{2.7}$, whereas pediatric criteria is more specific. Therefore, there is a lower false negative rate with adult criteria in detecting the presence of LVH. The specificity and sensitivity of pediatric criteria in detecting LVH are both poor.

In the current study, there were 8 individuals with LVMI >51 g/m$^{2.7}$ who were not diagnosed with hypertension by pediatric criteria, which is an alarming number given the data that exists associating severe LVH and poor outcomes.[15] All individuals with LVMI >51 g/m$^{2.7}$ met hypertension criteria by adult guidelines, further suggesting that it is a superior to pediatric criteria. Considering that the primary goal of hypertension criteria is to capture most, if not all, patients with risk of end organ damage, missing patients who already have clinically evident cardiac end organ dysfunction (LVH) is of concern. Since 2017, routine echocardiography in pediatric patients with hypertension is no longer recommended unless pharmacologic intervention is being considered; therefore, it is plausible that more individuals with LVH may be missed.[3]

Although the superiority of ABPM in predicting left ventricular changes in adults is well documented,[22-24] there are conflicting data regarding the association between current pediatric ABPM thresholds for the diagnosis of hypertension and LVH. Some studies have suggested that ABPM systolic pressures >95th percentile for age and sex were associated with increased likelihood for abnormal LVMI.[9,25] Others similarly found that ABPM measures of wake SBP index, wake DBP index, and sleep SBP load were significantly associated with concentric hypertrophy in children with primary hypertension.[26] However, the results of the current study are consistent with prior studies that found that the current pediatric ABPM guidelines are not predictive of LVH in children who are hypertensive.[27,28]

This ambiguity in the overall utility of the current ABPM guidelines is further complicated by their origins. The normative values that are used in the current pediatric ABPM diagnostic criteria for hypertension were first measured in 1997 from a homogenous population of European children, last updated in 2002. This brings into question their overall generalizability and effectiveness in diagnosing adolescents with hypertension in the US today.[29] Despite these drawbacks, ABPM has consistently been proven to be superior to office BP measurements in the diagnosis of hypertension and prediction of negative outcomes in adults, and is increasingly being used in the newest adult hypertension guidelines.[2]

There are limitations to this study. First, the study population was heterogeneous in terms of indication for ABPM.

Second, this is a single-center, retrospective study limited to 306 participants with ABPM data which could affect the generalizability of these results. Finally, echocardiography data within 6 months of the ABPM date were not available on a number of participants (47.4%), which could have affected the reliability of evaluating pediatric and adult criteria.

The current pediatric ABPM criteria appear to be inferior to the new adult ABPM criteria for the diagnosis of hypertension and LVH in our study population. Although adaptation of the adult ABPM criteria in the adolescent population may overcall the number of individuals with hypertension, those with LVH who are at greater risk for negative outcomes as adults are much more likely to be captured with these criteria changes. Further studies are needed to confirm these findings. A consideration to align the pediatric guidelines with adult criteria is warranted. ■

Submitted for publication Jul 23, 2020; last revision received Nov 3, 2020; accepted Nov 4, 2020.

Reprint requests: Christine B. Sethna, MD, EdM, Cohen Children's Medical Center of New York, Division of Nephrology, 269-01 76th Ave, New Hyde Park, NY 11040. E-mail: csethna@northwell.edu

## References


1. Chaudhuri A. Pediatric ambulatory blood pressure monitoring: diagnosis of hypertension. Pediatr Nephrol 2013;28:995-9.
2. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, et al. 2017. ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation 2018;138:e484-594.
3. Flynn JT, Kaelber DC, Baker-Smith CM, et al; Subcommittee on screening and management of high blood pressure in children. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics* 2017;140:e20171904. Pediatrics 2018;142:e20181739.
4. Siu AL. Screening for high blood pressure in adults: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 2015;163:778-86.
5. Kikuya M, Hansen TW, Thijs L, Björklund-Bodegård K, Kuznetsova T, Ohkubo T, et al. Diagnostic thresholds for ambulatory blood pressure monitoring based on 10-year cardiovascular risk. Circulation 2007;115:2145-52.
6. Soergel M, Kirschstein M, Busch C, Danne T, Gellermann J, Holl R, et al. Oscillometric twenty-four-hour ambulatory blood pressure values in healthy children and adolescents: a multicenter trial including 1141 subjects. J Pediatr 1997;130:178-84.
7. Wuhl E, Witte K, Soergel M, Mehls O, Schaefer F. Distribution of 24-h ambulatory blood pressure in children: normalized reference values and role of body dimensions. J Hypertens 2002;20:1995-2007.
8. Li Y, Thijs L, Boggia J, Asayama K, Hansen TW, Kikuya M, et al. Blood pressure load does not add to ambulatory blood pressure level for cardiovascular risk stratification. Hypertension 2014;63:925-33.
9. Sorof JM, Cardwell G, Franco K, Portman RJ. Ambulatory blood pressure and left ventricular mass index in hypertensive children. Hypertension 2002;39:903-8.
10. Flynn JT, Daniels SR, Hayman LL, Maahs DM, McCrindle BW, Mitsnefes M, et al. Update: ambulatory blood pressure monitoring in children and adolescents: a scientific statement from the American Heart Association. Hypertension 2014;63:1116-35.
11. Lai WW, Geva T, Shirali GS, Frommelt PC, Humes RA, Brook MM, et al. Guidelines and standards for performance of a pediatric echocardiogram: a report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr 2006;19:1413-30.
12. Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man. Anatomic validation of the method. Circulation 1977;55:613-8.
13. de Simone G, Daniels SR, Devereux RB, Meyer RA, Roman MJ, de Divitiis O, et al. Left ventricular mass and body size in normotensive children and adults: assessment of allometric relations and impact of overweight. J Am Coll Cardiol 1992;20:1251-60.
14. Khoury PR, Mitsnefes M, Daniels SR, Kimball TR. Age-specific reference intervals for indexed left ventricular mass in children. J Am Soc Echocardiogr 2009;22:709-14.
15. de Simone G, Devereux RB, Daniels SR, Koren MJ, Meyer RA, Laragh JH. Effect of growth on variability of left ventricular mass: assessment of allometric signals in adults and children and their capacity to predict cardiovascular risk. J Am Coll Cardiol 1995;25:1056-62.
16. de la Sierra A. New American and European hypertension guidelines, reconciling the differences. Cardiol Ther 2019;8:157-66.
17. Du T, Fernandez C, Barshop R, Chen W, Urbina EM, Bazzano LA. 2017 Pediatric hypertension guidelines improve prediction of adult cardiovascular outcomes. Hypertension 2019;73:1217-23.
18. Ogden CL, Carroll MD, Lawman HG, Fryar CD, Kruszon-Moran D, Kit BK, et al. Trends in obesity prevalence among children and adolescents in the United States, 1988-1994 through 2013-2014. JAMA 2016;315:2292-9.
19. McNiece KL, Gupta-Malhotra M, Samuels J, Bell C, Garcia K, Poffenbarger T, et al. Left ventricular hypertrophy in hypertensive adolescents: analysis of risk by 2004 National High Blood Pressure Education Program Working Group staging criteria. Hypertension 2007;50:392-5.
20. Swartz SJ, Srivaths PR, Croix B, Feig DI. Cost-effectiveness of ambulatory blood pressure monitoring in the initial evaluation of hypertension in children. Pediatrics 2008;122:1177-81.
21. Woroniecki RP, Kahnauth A, Panesar LE, Supe-Markovina K. Left Ventricular hypertrophy in pediatric hypertension: a mini review. Front Pediatr 2017;5:101.
22. Verdecchia P, Porcellati C, Schillaci G, Borgioni C, Ciucci A, Battistelli M, et al. Ambulatory blood pressure. An independent predictor of prognosis in essential hypertension. Hypertension 1994;24:793-801.
23. White WB. Ambulatory blood pressure and target organ involvement in hypertension. Clin Invest Med 1991;14:224-30.
24. Mancia G, Zanchetti A, Agabiti-Rosei E, Benemio G, De Cesaris R, Fogari R, et al. Ambulatory blood pressure is superior to clinic blood pressure in predicting treatment-induced regression of left ventricular hypertrophy. SAMPLE Study Group. Study on Ambulatory Monitoring of Blood Pressure and Lisinopril Evaluation. Circulation 1997;95:1464-70.
25. Richey PA, Disessa TG, Hastings MC, Somes GW, Alpert BS, Jones DP. Ambulatory blood pressure and increased left ventricular mass in children at risk for hypertension. J Pediatr 2008;152:343-8.
26. Shilly S, Merchant K, Singer P, Frank R, Gurusinghe S, Infante L, et al. Left ventricular cardiac geometry and ambulatory blood pressure in children. J Clin Hypertens (Greenwich) 2019;21:566-71.
27. Bjelakovic B, Jaddoe VW, Vukomanovic V, Lukic S, Prijic S, Krstic M, et al. The relationship between currently recommended ambulatory systolic blood pressure measures and left ventricular mass index in pediatric hypertension. Curr Hypertens Rep 2015;17:534.
28. Brady TM, Fivush B, Flynn JT, Parekh R. Ability of blood pressure to predict left ventricular hypertrophy in children with primary hypertension. J Pediatr 2008;152:73-8. 8.e1.
29. Patel SS, Daniels SR. Ambulatory blood pressure monitoring in pediatrics. Curr Hypertens Rep 2019;21:71.