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Research Article

Symmetric ambulatory arterial stiffness index in the young

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Abstract

The ambulatory arterial stiffness index (AASI) and the symmetric ambulatory arterial stiffness index (s-AASI) have been shown to correlate to arterial stiffness in adults. This study assesses these indices with anthropometric and blood pressure (BP) measures in children. A total of 102 children at a pediatric hypertension clinic who had ambulatory blood pressure monitoring (ABPM) done from 2009 to 2013 were included (75% males, 7-22yo, 47% hypertensive, 24% prehypertensive, and 34% white-coat hypertensives). AASI is 1 minus the regression slope of diastolic BP values on systolic BP values from a 24-hour ambulatory blood pressure monitoring. s-AASI is the symmetric regression of AASI. Obese patients had a significantly higher AASI. s-AASI correlated with systolic BP variability. In multivariable regression, BP variability independently correlated with AASI and s-AASI. s-AASI is related to systolic dipping.AASI and s-AASI are highly dependent on BP variability in children. Further studies are necessary to assess their utility. J Am Soc Hypertens 2016;10(6):500–505. © 2016 American Society of Hypertension. All rights reserved.

Keywords: AASI; hypertension; obesity; pediatrics.

Introduction

The ambulatory arterial stiffness index (AASI) is a measurement of arterial stiffness, derived from 24-hour ambulatory blood pressure monitoring (ABPM).[1] It is defined as 1 minus the regression slope of diastolic blood pressure (BP) values on systolic BP values.[2] Unlike other markers of arterial stiffness such as pulse wave velocity (PWV), brachial artery distensibility, and carotid artery ultrasound techniques, AASI requires no additional testing beyond ABPM.[3] In the adult population, AASI has been shown to be inexpensive, associated with preclinical organ damage, and predictive of cardiovascular mortality in hypertensive patients.[4] Furthermore, AASI has been shown to correlate with PWV and is able to independently predict cardiovascular mortality.[1,5] However, AASI in adults is dependent on the degree of nocturnal dipping, and a modification to this calculation, defined as symmetric AASI (s-AASI) and involving use of a bisector method, was devised to reduce that dependence.[6]

Simonetti et al[7] first demonstrated that AASI was correlated with hypertension in children. Another study done by Stergiou et al[8] evaluated AASI and pulse pressure as it relates to PWV in a hypertensive pediatric population. Their study demonstrated a better correlation between pulse pressure and PWV compared to AASI and suggests that this may be in part due to AASIs dependence on nocturnal dipping. A follow-up study recently examined the relationship between BP variables and PWV in children.[9] This study demonstrates an independent correlation between PWV and systolic BP variability. There was no significant correlation between PWV and AASI. As s-AASI is a modification of AASI that reduces its dependence on dipping, it may have a better correlation with BP variability as an index of arterial stiffness.

This study assesses the relationship of anthropometric and BP measures with AASI and s-AASI in the pediatric population. We hypothesize that AASI and s-AASI is associated with known risk factors for arterial stiffness such as obesity, age, and hypertension. Furthermore, AASI and

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s-AASI are correlated with known indicators of stiffness such as pulse pressure and BP variability. Finally, s-AASI is not correlated with dipping.

Methods

ABPMs performed at the Pediatric Hypertension Center at the Children's Hospital at Montefiore from July 2009 to January 2014 were reviewed. Inclusion criteria for ABPM were presence of at least 1 reading per hour and at least 40 readings total. Individual data points determined to be outliers were deleted from calculations. Exclusion criteria included any patients with a diagnosis of secondary hypertension (ie, coarctation of the aorta, renal disease, or syndromic patients) and any patients taking antihypertensive medications before the ABPM study.

Age, gender, height, weight, and body mass index (BMI) data were collected for each patient. Clinic BP was measured at rest (sitting or supine) with appropriate sized cuff by an aneroid device. Measurements were done on the right arm with auscultatory method using phase I and V Korotkoff sounds. Z scores for weight, height, BMI, and BP were calculated using the Lambda Mu Sigma tables published by the Centers for Disease Control. An oscillometric ABPM (Spacelabs Medical, Issaquah, WA, USA) was used and programmed to measure BP every 20 minutes during the daytime and every 30 minutes during the night. Patient diaries were used to define nocturnal versus daytime BP. Mean systolic and diastolic BP, BP loads, variability, and dipping were internally calculated by Spacelabs software. The diagnosis of white-coat hypertension, prehypertension, and ambulatory hypertension were based on clinic BP, mean ambulatory BP, and BP load.[10] White-coat hypertension was defined as having >95th percentile clinic BP but <95th percentile mean ambulatory BP and load <25%. Prehypertension is defined as >95th percentile clinic BP with <95th percentile mean ambulatory BP and load >25%. Ambulatory hypertension is defined as clinic BP and mean ambulatory BP > 95th percentile. Indices of BP were calculated as the BP value divided by the 95%ile for age and height. Obesity was defined as having a BMI z score ≥1.65.

AASI was calculated by the linear regression of each individual diastolic BP value versus the individual systolic BP values. It is defined as 1 minus the regression slope of diastolic BP values on systolic BP values derived from a 24-hour ABPM. s-AASI was derived by taking the symmetric regression of AASI. Both calculations' formulas were referenced from the calculations discussed in Gavish et al[11] original article on s-AASI. Please see the Appendix for detailed calculations used.

Descriptive statistics (mean ± standard deviation) were generated for all demographic characteristics. All variables were checked for normality. Means, confidence intervals, standard deviations, standard errors, ranges, *P* values, and equality of variances were calculated for all variables. Pearson correlation, multivariate linear regression, and independent samples *t* test were used where appropriate. Demographic information, anthropomorphic data, and all ABPM measurements and calculations were compared between obese and nonobese patients. Statistical analysis was performed using SPSS Statistics version 22.

Results

A total of 102 patients were included in this study. The age ranged from 7 to 22 years old (with a mean of 15.5 years), 46% were obese, and 75% were boys. The percentage of white-coat hypertensive, prehypertensive, and hypertensive patients were 34.3%, 22.5%, and 43.1%, respectively. BMI was incalculable in 10 patients as they did not have weight recorded. Additional measured variables are shown in Table 1.

Obesity and Blood Pressure

Table 2 demonstrates differences in variables when comparing obese versus nonobese patients. When comparing obese versus nonobese patients, there was no significant difference in absolute mean BP or pulse pressure values. There was a significant difference between AASI and 24-hour systolic, diastolic, and pulse pressure variability.

Anthropometric Data

Table 3 demonstrates correlations of AASI and s-AASI with anthropometric and BP variables. Of these variables,

Table 1
Clinical characteristics of the study population

Characteristics	Mean ± SD
Number	102
Age (y)	15.65 ± 2.90
Male (%)	72 (70.52)
Height (cm)	167.34 ± 13.31
Height z score	0.2 ± 1.22
Weight (kg)	79.91 ± 25.84
Weight z score	1.46 ± 1.15
BMI (kg/m^2)	28.32 ± 7.21
BMI z score	1.42 ± 1.01
24-Hour systolic pressure (mm Hg)	126 ± 8.93
24-Hour systolic variability	13.12 ± 2.45
24-Hour diastolic pressure (mm Hg)	70.75 ± 7.37
24-Hour diastolic variability	11.51 ± 2.20
24-Hour pulse pressure (mm Hg)	55.33 ± 7.43
24-Hour pulse pressure variability	10.00 ± 2.22
Systolic nocturnal dipping (%)	10.183 ± 6.61
Diastolic nocturnal dipping (%)	15.421 ± 8.57
AASI	0.41 ± 0.15
s-AASI	0.1 ± 0.13

AASI, ambulatory arterial stiffness index; BMI, body mass index; s-AASI, symmetric ambulatory arterial stiffness index; SD, standard deviation.