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Research Article

Assessment of vascular function in low socioeconomic status preschool children: a pilot study

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Abstract

Elevated brachial blood pressure (BP) in childhood tracks into adulthood. Central BP and measures of arterial stiffness, such as aortic augmentation index (AIx) and pulse wave velocity (PWV), have been associated with future cardiovascular disease. This pilot study assessed the feasibility of noninvasively measuring these parameters in preschool children and explored factors that may be associated with elevated BP in this age group. Brachial BP was measured using an electronic oscillometric unit (Dinamap PRO 100) and defined as elevated when systolic BP (SBP) and/or diastolic BP (DBP) was ≥ the 90th percentile for age, gender, and height. Central BP, AIx, and PWV were measured using applanation tonometry (SphygmoCor). C-reactive protein (CRP) was measured in serum samples. Sixteen African-American preschool children were recruited (4.4 ± 0.8 years, 69% males), 6 (38%) of whom had an elevated brachial BP (110 ± 10/69 ± 4 vs. 96 ± 8/55 ± 6 mm Hg, Cohen's d = 2.2). Children with elevated brachial BP had higher central SBP (d = 1.6) and DBP (d = 1.96) (97 ± 6/68 ± 4 vs. 85 ± 8/57 ± 6 mm Hg), AIx (d = 0.88) (31 ± 8 vs. 18 ± 16%, standardized to heart rate), and CRP (3.1 [2.3–6.3] vs. 0.1 [0.1–0.3] mg/dL, d = 2). There was no significant difference in PWV between groups (d = 0.26). CRP and SBP (Spearman r = 0.70), DBP (r = 0.68), central SBP (r = 0.58), and central DBP (r = 0.71) were positively correlated. Wide confidence intervals for the estimated effect sizes indicated a large degree of uncertainty about all estimates due to the small sample size. Noninvasive assessment of central BP and arterial stiffness is feasible in preschool children. Vascular inflammation may be an important factor that influences BP at an early age. Further studies in preschool children are needed to elucidate mechanisms of early onset hypertension. J Am Soc Hypertens 2016;■(■):1–9.

Keywords: Aortic stiffness; hypertension; vascular inflammation.

Conflict of interest: None.

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Worldwide, more than 1 billion people have hypertension (HTN), which is estimated to account for 7.1 million deaths annually.[1] In the United States (US), over 80 million adults and an estimated 2–3 million children have HTN, an important risk factor for cardiovascular disease (CVD), the leading cause of death worldwide.[2] Given current trends, it is projected that an additional 27 million US adults will develop HTN by 2030.[3] There is increasing evidence that CVD risk factors, including HTN, appear in childhood and track to adulthood.[4–6] Therefore, it is important to identify children at high risk of developing CVD later in life in order to introduce preventive interventions at an early time point.

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Elevations in noninvasive measures of vascular function, including arterial stiffness indexed by aortic pulse wave velocity (PWV), aortic augmentation index (AIx), and central blood pressure (BP), are associated with premature CVD in adults.[5] It is now widely recognized that vascular inflammation, which can be assessed by serum C-reactive protein (CRP) levels, is an important contributor to vascular health and has been associated with the development of CVD and CVD events in individuals without clinically apparent disease.[7]

Few studies have assessed vascular function in children. Lurbe et al[8] evaluated PWV in 8- to 18-year-old children and adolescents and demonstrated a progressive increase in PWV with increasing BP. Although BP elevations may be evident in preschool children,[9] very few studies have assessed vascular function in this age group. Further, we lack data on factors that influence BP and vascular function at an early age.

The principal aim of the current study is to assess the feasibility of noninvasively measuring central BP, AIx, and PWV in 3- to 5-year-old preschool children. A secondary aim is to explore factors that may be associated with elevated brachial and central BP and aortic stiffness in this age group.

Methods

Study Participants

We conducted a pilot study in low socioeconomic status (SES) preschool children recruited from urban Head Start/Early Head Start (HS/EHS) programs Birmingham, Alabama. The HS/EHS program, sponsored by the US Department of Health and Human Services, provides comprehensive early childhood education, health, nutrition, and parental involvement services to low-income children and their families.[10]

Inclusion criteria included the following: (1) enrollment in an HS/EHS program; (2) age 3–5 years at time of study; (3) parental informed consent; and (4) ability to understand instructions, speak, and understand English. Important exclusion criteria included the following: (1) febrile illness, (2) known congenital heart disease, (3) reported chronic disease or recent viral illness by the child or his/her caregiver, and (4) any visible signs of viral illness. The study was approved by the UAB Institutional Review Board and was conducted according to institutional guidelines.

Demographics, Height, Weight, and Waist Circumference

Age, gender, race, and existing medical conditions of the participants were assessed based on parental responses to a standardized demographic questionnaire. Height was measured in inches using a portable stadiometer, and weight was measured in pounds and ounces by a digital scale according to a standard protocol.[11] Body mass index (BMI) was calculated based on the formula BMI = body weight in kilograms/body height in meters squared. BMI percentile for age, gender, and height was calculated based on the CDC growth charts.[12] Children with a BMI $\geq$85th percentile were considered overweight.

BP Measurement

BP was measured using an electronic oscillometric unit (Dinamap PRO 100) according to the protocol developed by the National High BP Education Program Working Group on Hypertension Control in Children and Adolescents.[13] Each child rested for 5 minutes in the seated position, while an age-appropriate children's book was read to her/him prior to and during BP measurements. BP was measured twice, one minute apart. The mean of the two systolic (SBP) and the diastolic (DBP) brachial BPs was used to classify children as being normotensive (SBP and/or DBP $<$ the 90th percentile for age, gender, and height) or having elevated BP (SBP and/or DBP $\geq$ 90th percentile).[13] We then calculated form factor, an indicator of pulse wave shape, FF = (MAP − DBP)/pulse pressure (mean arterial pressure [MAP]).[14]

Laboratory Evaluation

Blood samples were collected by fingerstick ($<$0.5 mL). Serum was separated, aliquoted, and stored in a −80°C freezer to avoid multiple freeze-thaw cycles. A commercial high-sensitivity CRP ELISA kit (GenWay Biotech, San Diego, CA, USA) that has a coefficient of variation of 5% at a mean CRP of 0.004 mg/L was used to measure circulating CRP as an indicator of vascular inflammation. All specimens were measured in duplicate.

Pulse Wave Analysis and PWV Assessment

In addition to the operator, two nurses and the caregiver (mother for the majority of the children) were present in the room throughout the assessment. The nurses read an age-appropriate book to the child before and during the procedure. The study procedure was demonstrated on a doll in front of the children immediately before starting, and the child was given a chance to apply the tonometer on the doll. This was followed by tonometer application on the child's arm so that he/she would not be alarmed when the assessment was done. The assessment did not start until the child was comfortable, and the questions of the child and caregiver were answered.

Aortic PWV was calculated from measurements of common carotid and femoral artery waveforms using an automated applanation tonometry-based device (SphygmoCor system-AtCor Medical, Sydney, NSW, Australia). All