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Childhood obesity and blood pressure: back to the future?

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The prevalence of childhood hypertension is increasing.^{1, 2} Studies that apply the 95th percentile definition and repeat measurements on three separate visits, report a pediatric hypertension prevalence of approximately 3.5%^{3, 4}, and among obese children and adolescents the prevalence of both hypertension and prehypertension is even greater. The recently documented increase in hypertension among the young is due largely to the childhood obesity epidemic and possibly other secular changes in lifestyles. These publications and others confirm that hypertension is a prevalent child health condition, especially among overweight and obese children. A consistent positive association between body size and blood pressure level has been observed throughout childhood and adulthood. The report in this issue by Tu et al⁵ add additional insights on the impact of excess adiposity on blood pressure levels in childhood.

To determine if the relationship, in childhood, of blood pressure with body fat, or relative adiposity, is linear as opposed to there being a threshold effect of adiposity, these investigators analyzed data from a cohort of healthy children who had been recruited from Indianapolis schools and examined longitudinally. Body mass index (BMI) percentile, which adjusts for age and sex in children, was used to quantify relative adiposity; and blood pressure percentile, which adjusts for age, sex, and height, was used to quantify relative blood pressure level. Systolic or diastolic blood pressure $\geq 90^{\text{th}}$ percentile was the cut-point for high blood pressure.⁶ They found, as depicted in figure 2 of their report, that the prevalence of high blood pressure in the child cohort was low and approximately the same across BMI percentiles up to the 85th percentile for BMI. Once the 85th BMI percentile was exceeded there was a marked increase in the prevalence of high blood pressure. In children, a BMI percentile from 85th to 95th defines

“overweight”, and ≥ 95 th BMI percentile defines “obese.” Currently the term overweight in children has been used only to designate a higher risk for developing obesity. The data by Tu et al clearly demonstrate a marked increase in high BP among children when BMI reaches the overweight range. The implication is that childhood overweight may not be benign but could herald more significant problems.

The data presented by Tu and colleagues in this issue (Figure 2) are remarkably similar to a previous publication on a cohort of children in Iowa examined prospectively from 1971 to 1981 in the Muscatine Study. Lauer and Clark analyzed the childhood data to determine what parameters were leading determinants of high blood pressure ($\geq 90^{\text{th}}$ percentile) in young adulthood. They found that high blood pressure by age 20 to 30 years was significantly associated with blood pressure in childhood; but the strongest childhood predictor of high blood pressure in young adulthood was relative adiposity, which these investigators quantified by the Quetelet index (Weight in Kg/Height in meters³). The figure is reproduced from the Lauer and Clark publication in 1989.⁷ The regression curves depict the risk for high blood pressure in young adulthood from childhood blood pressure percentiles (dashed and dotted lines) and from childhood Quetelet index percentile (solid line). In both males and females, childhood blood pressure percentile confers an increasing risk for adult high blood pressure. The most striking part of the figure is the sharp upward shift in the curve for Quetelet index that occurs at approximately the 85th percentile. The 1989 Lauer and Clark publication describe a risk for future high blood pressure that rises over four-fold when relative adiposity in childhood (Quetelet index) exceeds the 85th percentile. The publication by Tu et al in this issue, based on data obtained decades later than the Muscatine study,

demonstrates a similar four-fold increase in risk for high blood pressure when BMI during childhood exceeds the 85th percentile; but the risk for high blood pressure is in childhood, not later in adulthood. The findings are the same, but results reported by Tu and colleagues tell us that obesity associated morbidities commonly observed in adults are present in childhood and the risk increases markedly as children become overweight.

It is currently estimated that the prevalence of obesity among US children from 2 to 19 years of age is 16.3%. When overweight is added, the percent of US children with BMI \geq 85th percentile increases to 31.9%.⁸ The reality of the childhood obesity epidemic has now gained public attention with emerging efforts underway to modify health related behaviors that contribute to onset and progression of childhood obesity. Less attention has been given to the “overweight” category of excess adiposity, other than designating overweight a risk for becoming obese. The publication by Tu and colleagues, as well as the older publication by Lauer and Clark provide evidence that the overweight in childhood should be recognized as a heightened risk condition with more emphasis on interventions directed at lowering BMI below the 85th percentile in overweight children.

The strong association between high blood pressure and obesity in childhood raises concern about premature onset of chronic disease in early adulthood. In 2004, the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents⁶ recommended that the evaluation of children with confirmed hypertension include evaluation for associated risk factors and target organ damage as well as basic evaluation for underlying causes of the hypertension. Following that publication in 2004, reports from cross-sectional studies on children with high blood pressure confirm that target organ damage is detectable in the young. Left ventricular

mass $\geq 95^{\text{th}}$ percentile, quantified by echocardiography, is detectable in a substantial portion of children with primary hypertension.⁹ Compared to normotensive children, a measurable increase in carotid intima-media thickness has been reported in children with hypertension compared to those with normal blood pressure.¹⁰ Increased arterial stiffness, or loss of elasticity, a change generally associated with aging, has been detected in pediatric patients with high blood pressure as well as obesity, diabetes, and dyslipidemia.¹¹ Even subtle cognitive changes, in areas of executive function, are now described in children with hypertension.¹² Based on these findings, primarily described in adolescents, high blood pressure in the young is more than risk for future target organ damage. The emerging evidence indicates that target organ damage is already underway in a portion of children with high blood pressure.

Most, but not all, children and adolescents with primary hypertension have associated obesity or overweight. This raises the question as to whether or not the percentiles method for defining high blood pressure should be based on blood pressure data obtained from cohorts that include all children or be restricted to only normal weight children. Blood pressure percentiles for children and adolescents with BMI $< 85^{\text{th}}$ percentile have been published¹³ and the blood pressure levels, adjusted for sex, age, and height, for the 90th and 95th percentiles are somewhat lower than reference values in the Fourth Report.

Pediatric primary care clinicians have the major burden in prevention and early detection of excess adiposity as well as other risk factors for chronic health issues in individual children, but they should not have the sole responsibility in solving the problem of childhood obesity. Although there is now public awareness about childhood

obesity, there are substantial needs in delivery of childhood health care, public health programs and health policies to support and reinforce prevention and early intervention on childhood obesity, high blood pressure and other co-morbidities associated with excess adiposity.

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Figure legend:

The figure is reproduced from Lauer and Clark⁷ and depicts the risk in males for high BP in young adulthood (y axis) versus childhood systolic BP percentile (dashed regression line), childhood diastolic BP (dotted line), and Quetelet index percentile (solid line).

There is a four fold increase in risk for high BP in young adulthood as childhood Quetelet index exceeds the 85th percentile. Similar results were depicted for females (not shown).

