Assessment and Management of Hypertension in Children and Adolescents: Part A- Epidemiology, Clinical Evaluation and Prognosis

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Abstract
The renewed interest in hypertension in children and adolescents has resulted from the recognition that its presence in adults often has its roots at a younger age. Accurate measurement of blood pressure in children is essential to establish a diagnosis and it should be based on an appropriate technique and comparison to well established population-based standards. The causes are multiple in young children and a thorough evaluation of possible primary causes is imperative.

Keywords: Adolescent, blood pressure, child, humans, hypertension.

Introduction
Hypertension is a common disease in adults, with a prevalence which increases with age, ranging from 15% in young adults to 60% in persons over the age of 65 years. Approximately one-third of affected people are unaware of this problem and an equal proportion has blood pressure control below recommended goals.1 Hypertension is associated with high morbidity, as shown by the 7th Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure where each 20 mm Hg increment in systolic or 10 mm Hg diastolic pressure has been shown to double the risk of cardiovascular disease.2 In adults, this morbidity decreases with better control of the blood pressure, with a reduction in the risk of coronary heart disease, stroke, renal disease, and congestive heart failure.3 Although the measurement of blood pressure in children is now recommended during any routine physical examination, the paediatricians' interest in this subject has only developed over the past four decades, resulting in the publication of the first report of the Task Force on Blood Pressure Control in Children.4 Norms for blood pressure in children and adolescents and definitions of hypertension have been revised many times since, with updated recommendations and norms.5, 6 The most recent classification for blood pressure in children and adolescents was recommended by the United States National High Blood Pressure Education Program (NHBPEP) Working Group in 2004.7 Despite its limitations, such as dependence on a single blood pressure measurement per child, and measurement with a mercury sphygmomanometer, this classification has been adopted worldwide.

However, our understanding of blood pressure in children and adolescents is far from being complete and the long-term natural history of...
blood pressure in this age group is still not well understood. In adults, the definition of hypertension is based upon outcomes such as myocardial infarction and stroke, with their incidence increasing linearly with blood pressure measurements. It has been estimated that for each 5 mm Hg increase in diastolic blood pressure, the risk of coronary artery disease increases by 20% and the risk of stroke by 35%. As these outcomes are extremely rare in children and adolescents, the definition of elevated blood pressure in the young remains largely only a statistical one, derived from population-based databases of blood pressures measured in healthy children. It must be emphasized, however, that reports from small populations of children have recently confirmed that a relationship also exists between hypotension and both ventricular hypertrophy and atherosclerosis, as described in adults.

**Epidemiology**

The accurate incidence of hypertension in children and adolescents is not well defined. The reasons are many. They include the absence of large pediatric population-based cohort studies. In addition, by defining hypertension when blood pressure measurement exceeds the 95th percentile, it would be expected that its prevalence would be approximately 5%. However, due to the effects of regression to the mean with repeated measures, using the recently recommended three separate measurements in children with an initial blood pressure measurement above the 95th percentile, the prevalence of hypertension is, in fact, much lower, between 1% and 3%. Another reason is that, in the absence of hypertension-related outcomes, data in childhood, the definition of hypertension in that age-group remains rather arbitrary and is based exclusively on population-based frequency-distribution curves for blood pressure. Furthermore, reported incidences vary from country to country and even from region to region in the same country, because of differences in genetic and environmental factors, regional differences in the definition of high blood pressure, the distribution of reference blood pressure data, and measurement methodology.

Recently, more precise estimates of the prevalence of hypertension in childhood have been published. By using repeated measurements on separate visits to define hypertension and pre-hypertension in a cohort of 14,000 children and adolescents between the ages of 3 years and 18 years who presented to well-child care visits, the prevalence of hypertension was estimated to be 3.6% and that of pre-hypertension 3.4%. In a cross-sectional study of 7,000 high school students aged between 11 and 17 years, using the recommended repeated blood pressure measurements on those with an elevated initial measurement, the prevalence of hypertension was found to be 3.2% and the prevalence of pre-hypertension 15.7%. Over the past few years, an increased prevalence of 4.5% has been reported in school-based blood pressure screening of a cohort of over 5,000 children. This might have been the result of an increased prevalence of obesity. While the majority of these children had mild hypertension, most often primary (essential), a small group had much higher blood pressures usually due to a secondary cause. The prevalence of persistent secondary hypertension in children has been estimated to be 0.1%, with renal disease being the predominant etiology.

Race, sex, anthropometric measurements and family history do not have the same impact on blood pressure in children as they have in adults. Although peripheral vascular resistance and blood pressure sensitivity to salt intake are, at any age, higher in African American than in Caucasian children, no significant differences in blood pressure have been found until adolescence. As a result, the reference standards for blood pressure in children do not now distinguish between racial or ethnic groups. Blood pressure is slightly higher in boys than in girls during the first decade of life, but, from the onset of puberty, it becomes significantly higher in young males. Height is independently related to blood pressure at all
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ages and it has, therefore, now been taken into consideration by the Task Force on Blood Pressure Control in Children when they published their data. A familial influence on blood pressure exists early in life, with children from families with hypertension tending to have higher blood pressures than children from normotensive families. While significant correlations in blood pressure and cardiovascular risk factors between parents and their biological children have been observed since the neonatal period, the correlation in blood pressure between parents and adopted children is significantly lower. The greater correlation in blood pressures between children and their mothers compared to their fathers suggests a direct prenatal influence. Siblings of hypertensive children also have significantly higher blood pressure than siblings of those with normal blood pressure. Concomitant obesity in both parent and child could also explain some of the correlation between the blood pressure of parents and that of their offspring as well as the familial aggregation of blood pressure observed early in life. Obesity is associated with a higher prevalence of hypertension. The direct relation, observed as early as five years of age, becomes more evident in the second decade. Depending on ethnicity, the combined prevalence of hypertension and pre-hypertension in high school students is over 30% in obese boys and 23–30% in obese girls. Studies by the National Health and Nutrition Examination Surveys group have reported a significant increase in both systolic and diastolic blood pressure from 2.7% in the 1988–1994 survey to 3.7% in the 1999–2002 survey, mostly associated with obesity. With the current childhood obesity epidemic it is therefore expected that the prevalence of hypertension in children and adolescents will increase further.

Measurement and Recording of Blood Pressure

Proper measurement and evaluation of blood pressure in children require special considerations. Conventional sphygmomanometers and auscultation should be used rather than automated devices, because the current blood-pressure standards are based on these measurements, and no standards for automated devices are available as yet. Doppler and oscillometric techniques can however be used in children in whom auscultatory blood pressure measurements are difficult to obtain because of lack of cooperation and anxiety. They are best for measuring mean blood pressure, but are susceptible to artifacts. The oscillometric method is very accurate for measuring systolic blood pressure, but is less accurate for diastolic pressure. The correlation coefficient between intra-arterial and oscillometric measurements is 0.97 for systolic and 0.90 for diastolic blood pressure, although the accuracy decreases in smaller infants. It is important however that measurements obtained by using oscillometric devices that exceed the 90th percentile should be repeated with auscultation.

The use of an appropriate-sized blood-pressure cuff is essential for accurate measurement. This involves measuring the circumference of the right upper arm at the midpoint between the acromion and olecranon and selecting a cuff whose rubber bladder width, inside the cloth layer, covers at 40 to 60% of the patient’s arm circumference and whose length covers 80–100% of the arm circumference. Use of an inappropriately small cuff may falsely elevate the blood pressure reading, whereas the use of too large a cuff will give a falsely low reading. When two cuffs are close in size to the measured arm width, the larger cuff should always be selected.

Measurements should be taken after 3 to 5 minutes of resting. The child should be relaxed and in a comfortable, preferably sitting position, with the feet on the floor and the back supported. The right arm should be resting on a supportive surface at the level of the heart. Infants can be examined while supine. The cuff should be inflated at a pressure approximately 20 mm greater than
that at which the radial pulse disappears and then allowed to deflate at a rate of 2-3 mm Hg per second.

The first Korotkoff sound, which is the appearance of a clear tapping sound, defines the systolic pressure, whereas the fifth Korotkoff sound, which is the disappearance of all sounds, defines the diastolic pressure. The fourth Korotkoff sound, which is a low pitched, muffled sound and the fifth sound may frequently occur simultaneously, or the fifth sound may not occur at all. Until recently, the phase 4 Korotkoff sound was used to designate diastolic blood pressure in children less than 13 years of age and the phase 5 Korotkoff sound was used for diastolic blood pressure in children over the age of 13 years. With the availability of more epidemiologic blood-pressure data on children and a reanalysis of previous data, it has now been accepted that the fifth Korotkoff sound is a reliable measure of diastolic blood pressure for children of all ages. When Korotkoff sounds can be heard down to 0 mm Hg, the blood pressure measurement should be repeated while applying less pressure to the head of the stethoscope.

Measurements must always be repeated over time to obtain meaningful information. When elevated systolic blood pressure is found in the upper extremities, it is imperative that it is also always measured in the lower extremities. With the child in the supine position, place a cuff on the calf, choosing a cuff wide enough to cover at least two thirds of the distance from the knee to the ankle. Normally the systolic pressure in the arm should never exceed that in the foot. Increased systolic pressure in the arm and decreased in the lower limbs suggests coarctation of the aorta. In such a situation, systolic blood pressure must also be measured in the left arm and leg, as hypertension found only in the right arm would suggest that the coarctation is proximal to the origin of the left subclavian artery.

Ambulatory blood pressure monitoring (ABPM) is based on the principle that repeated measurements of blood pressure throughout a 24-hour period provide a better estimation of true blood pressure than a single measurement. However, the experience with ambulatory blood-pressure monitors in children is limited, and reliable population standards are not available as yet. In addition, as ABPM values have not been precisely correlated with single or repeated conventional cuff measurements, cuff and ABPM measurements cannot be used interchangeably, either for clinical management or in trials of antihypertensive medications; both types of measurements therefore should be evaluated separately according to their respective standard tables. ABPM is helpful in diagnosing white-coat hypertension and may be especially useful in adolescents who have borderline hypertension in the office setting.

Recent standards of care recommend yearly blood pressure measurement in every child older than 3 years, preferably by means of auscultation with a mercury gravity manometer. However, data regarding the recommended frequency of these measurements during childhood to improve health status are not currently available.

Normal Blood Pressure Values
Blood pressure in children is classified according to the percentile distribution of the measurements within the paediatric population. Tables derived from epidemiologic studies of 70,000 children and adolescents have initially defined blood-pressure reference standards according to age only. These standards have been revised several times since, including the 1988–1991 National Health and Nutrition Examination Survey, taking into consideration the effects of both age and height on blood pressure. More recently, the Fourth Report added normative data, adapting them to the growth charts from the Centers for Disease Control and Prevention. In accordance with the recommendations of the Task Force, blood pressure is considered normal when the systolic and diastolic values are less than the 90th percentile for the child's age, sex, and height.
**Definition of Hypertension**

An ideal definition of hypertension would be based on a threshold level of blood pressure that divides children between those at increased risk of adverse outcomes and those who are not. The most recent normative values are based on the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. It should be noted however that all measurements used in constructing all previous and the most recent task force tables have all been made with a standard mercury sphygmomanometer.

As children may develop anxiety during blood pressure measurement, this might lead to a false diagnosis of hypertension. Therefore, whenever mild hypertension is found, it is imperative that the measurements are repeated twice more over a period of a few weeks, as this decreases anxiety because the child becomes more and more comfortable with the repeated measurement procedure. Another reason why blood pressure readings tend to decrease with repeated measurements is the statistical phenomenon of regression towards the mean. These factors explain why the true prevalence of hypertension after repeated measurements is considerably lower than after a single measurement, as demonstrated in several studies. The prevalence of more severe hypertension is even lower. It is therefore recommended that the average of these multiple measurements of blood pressure is plotted on an appropriate percentile chart. Should there be a discrepancy between the systolic and diastolic classifications of hypertension, the higher value should be used.

**Classification of Hypertension**

**Pre-hypertension**

The condition is diagnosed when a child’s average blood pressure exceeds the 90th percentile but remains less than the 95th percentile. Any adolescent whose blood pressure is greater than 120/80 mm Hg is also labeled as having pre-hypertension even when their reading is less than the 90th percentile. Children diagnosed to have pre-hypertension should always be evaluated for risk factors such as obesity and also followed up at 6-monthly intervals as they are more likely to develop overt hypertension in the future.

**Stage I Hypertension**

A child is said to have stage I hypertension when his/her average systolic and/or diastolic pressure is greater than the 95th percentile for gender, age and height on at least 3 occasions, but inferior or equal to the 99th percentile plus 5 mm Hg. Use of the 24-hour ambulatory blood pressure monitoring should be strongly considered as the first step of evaluation and confirmation in the majority of such cases. If hypertension is confirmed, evaluation should proceed and therapy considered.

**Stage II Hypertension**

This is diagnosed when a child’s blood pressure is greater than the 99th percentile plus 5 mm Hg. These children should be reevaluated after one week, or sooner if they are symptomatic. Prompt referral is indicated for evaluation and therapy, especially if the child is symptomatic.

**White-Coat Hypertension**

A child with blood pressure levels above the 95th percentile in a physician’s office, but who is normotensive outside a clinical setting or by ambulatory blood pressure monitoring is said to have white-coat hypertension. This phenomenon may be seen in up to 60% of children referred for the evaluation of elevated blood pressure. It is important to identify white-coat hypertension, since it does not appear to be associated with the development of target-organ damage and further evaluation may not be needed. Ambulatory monitoring of blood pressure is usually required to diagnose this condition. Although these children appear to have a relatively benign outcome compared to those with sustained hypertension, they may be at increased risk of sustained hypertension and cardiovascular disease in the future. However the risk of cardiovascular...
complications seems to be low as long as the ambulatory pressure remains normal.

Masked Hypertension
This is the opposite phenomenon to white-coat hypertension. It is described when office blood pressures are normal but the child or adolescent is actually hypertensive. Masked hypertension is especially important to identify in children with underlying renal disease as elevated blood pressures may contribute to the progression of renal insufficiency. Masked hypertension can also be detected by ambulatory blood pressure monitoring.

Screening for Hypertension
The awareness that adult essential hypertension has its origin in childhood has resulted in increased emphasis on screening. Current consensus recommendations state that blood pressure should be measured in all children from the age of 3 years at all medical encounters, as well as in selected children under the age of 3 years if they are at risk of hypertension. Children are at increased risk of hypertension when there is a history of prematurity, very low birth weight, neonatal intensive care interventions, congenital heart disease, recurrent urinary tract infections, known renal or urological diseases, haematuria or proteinuria, family history of congenital renal disorders, malignancy and post organ transplant. They are also at increased risk if they have conditions known to be associated with hypertension, such a neurofibromatosis, tuberous sclerosis or ambiguous genitalia. Accurate techniques for measurement of blood pressure are necessary for the diagnosis and staging of hypertension in children at increased risk and also for follow up.

Aetiology
Hypertension can be primary (essential) or secondary. In general, the younger the child and the higher the blood pressure, the greater the likelihood that hypertension is secondary to an identifiable cause.

A secondary cause of hypertension is most likely to be found before puberty where approximately 78% have a renal parenchymal abnormality. Some causes are also commoner in specific age groups.

Hypertension in the newborn is most often associated with umbilical artery catheterisation and renal artery thrombosis.

In infants, causes include renal artery or vein thrombosis, congenital renal anomalies, coarctation of the aorta and bronchopulmonary dysplasia.

Between the age of 1 and 6 years, causes include renal artery stenosis, renal parenchymal disease, Wilms tumor, neuroblastoma and coarctation of the aorta.

Between the age of 7 and 12 years, causes include renal parenchymal disease, renovascular abnormalities, endocrine causes and essential hypertension. In all ages, renal and renovascular hypertension accounts for the majority of children with secondary hypertension. Causes include urinary tract infection, vesicoureteric reflux, obstructive uropathy, cortical renal scarring, renovascular hypertension, acute or chronic glomerulonephritis, and Wilms tumor. Endocrinopathies can also cause secondary hypertension. They include hyperthyroidism, hypercalcaemia (secondary to hyperparathyroidism or to other causes), adrenocortical disorders (aldosterone-secreting tumors, congenital adrenal hyperplasia, Cushing syndrome) and pheochromocytomas.

In adolescents, other causes should also be sought. Medications or illicit drugs may be the primary cause of hypertension: cocaine may provoke a rapid increase in blood pressure and phencyclidine may cause transient hypertension that may become persistent in chronic abusers. In addition tobacco, sympathomimetic agents used as nasal decongestants, appetite suppressants, and stimulants for attention deficit disorder and oral contraceptives in adolescent girls can also induce hypertension. Immunosuppressant agents such as cyclosporine and tacrolimus cause hypertension in organ transplant recipients, and the effect is exacerbated by the co-administration of corticosteroids.
After puberty, hypertension is likely to be essential and is often accompanied by a strong family history. The underlying causes are likely to be multifactorial: obesity, diet, stress, genetic alterations in calcium and sodium transport, vascular smooth muscle reactivity, renin-angiotensin system, and insulin resistance. It must be stressed however that there are no accurate data on the prevalence of essential hypertension in children as reviews of the causes of hypertension in childhood and adolescence have often relied on data from medical centres where children with severe hypertension are referred, with the majority of whom having secondary causes for their hypertension. However, since the recent incorporation of blood-pressure measurement into the routine physical examination of high school students, it has been shown that, in most cases, essential hypertension is the most common cause of mild to moderate hypertension. Secondary causes are found much less frequently in hypertensive adolescents, and when they exist, renal disease continues to be the most common cause.

**Presentation**

The circumstances of diagnosing hypertension in children and adolescents are varied. Those with essential hypertension are usually asymptomatic; the hypertension is usually mild and detected during a routine examination. Similarly, unless the blood pressure has been sustained for a long time or is particularly high or rising rapidly in children with secondary hypertension, hypertension is also asymptomatic, and any clinical manifestations will be those of the underlying disease, such as growth failure in children with chronic renal disease. Sometimes the presence of co-morbid factors may be the first clue to the diagnosis of hypertension, such as obesity.

In other instances, hypertension might be symptomatic. Patients with severe hypertension may present with headache, vision changes, epistaxis, or nausea. Young infants may present acutely with signs and symptoms of congestive heart failure. Hypertensive emergencies may also be the initial mode of presentation with severe hypertension associated with life-threatening or organ-threatening complications, such as encephalopathy (seizures, stroke, focal deficits), acute heart failure, pulmonary edema or acute renal failure.

**Clinical Evaluation**

**History**

A well-taken history may reveal important clues about the cause of hypertension and may help guide the necessary investigations. Important information to seek from the history include the following:

- Prematurity
- Bronchopulmonary dysplasia or chronic lung disease
- History of umbilical artery catheterisation
- Growth failure
- History of head or abdominal trauma
- Family history of hypertension, neurofibromatosis, polycystic kidney disease
- Medication history such as corticosteroids, tricyclic antidepressants, cold remedies, amphetamines or medications for attention deficit hyperactivity disorder
- Episodes of pyelonephritis that may result in renal scarring
- Dietary history, including caffeine, licorice, and salt consumption
- Smoking, drinking alcohol, and use of illicit substances

**Clinical Examination**

The objectives of the physical examination are:

1. search for a possible primary cause of secondary hypertension
2. identify the associated risk factors and co-morbidity
3. assessment of any hypertension-induced target-organ damage
1. Search for a Primary Cause for Hypertension

Anthropometric measurements such as height, weight and body mass index should be accurately measured and plotted on a sex-specific growth chart, to detect growth failure or obesity.

On inspection, the presence, pallor, growth failure and edema may suggest chronic renal impairment. Physical evidence of rickets should evoke the possibility of chronic renal disease.

In the child is very thin, the possibility of an underlying pheochromocytoma, renal disease or hyperthyroidism should be raised.

The presence of dysmorphic features may suggest an underlying condition associated with hypertension, such as:

- an elfin facies may be suggestive of Williams syndrome especially when associated with growth failure, heart murmur and mental retardation.
- webbing of neck, low hairline, widespread nipples with cubitus valgus may suggest Turner syndrome.
- a round “moon” face, buffalo hump, hirsutism, truncal obesity and striae may suggest Cushing syndrome.
- polydactyly, truncal obesity and hypogonadism may be suggestive of Bardet-Biedl syndrome.
- angiomatosis, and café au lait spots may suggest the possibility of Von Hippel-Landau syndrome.

Inspection and palpation of the neck is necessary to look for the presence of goiter.

The genitalia should always be examined as the presence of ambiguous genitalia or of virilisation may lead to the diagnosis of congenital adrenal hyperplasia, and the presence of hypogonadism to the possibility of Bardet-Biedl syndrome.

Skin examination is very helpful. Finding café au lait spots or neurofibromas suggests the presence of pheochromocytoma associated with neurofibromatosis type I. Similarly, the discovery of tubers, facial angiofibromas (“adenoma sebaceum”), periungual fibromas, “ash-leaf” depigmented spots may suggest the diagnosis of tuberous sclerosis. The presence of acanthosis nigricans would suggest the presence of the metabolic syndrome. Systemic lupus erythematosus might be suggested if a malar rash is seen. A non-blanching vesiculotrichic rash on the lower limbs with arthritis would be suggestive of Henoch-Schonlein purpura. The presence of needle tracks may suggest illicit drug use. The presence of bruises and striae would be suggestive of the diagnosis of Cushing syndrome. Witnessing sudden episodes of pallor, with evanescent flushing and sweating might evoke the possibility of pheochromocytoma.

The eyes should be carefully examined for proptosis or exophthalmos suggestive of hyperthyroidism, for extraocular muscle palsy or fundal changes suggestive of raised intracranial pressure and always for hypertensive retinal changes.

A thorough cardiovascular examination is mandatory. The paediatrician should look for the presence of cardiomegaly, heart murmurs, bruits over the great vessels (arteritis or arteriopathy), pericardial friction rub (effusion secondary to chronic renal disease). The presence of hepatomegaly should be sought and the pulse should be examined for rate and rhythm (atrial fibrillation secondary to hyperthyroidism). Palpation of the femoral arteries is of paramount importance in any child with hypertension as absent or diminished femoral pulses, associated with lower blood pressure in the lower limbs compared to the upper limbs is highly suggestive of coarctation of the aorta.

Examination of the respiratory system would reveal the presence of chest deformities, overinflation and other signs indicative of the presence of bronchopulmonary dysplasia. Auscultation should look for signs of pulmonary edema (secondary to congestive heart failure related to an acute glomerulonephritis or critical aortic coarctation).
A careful examination of the abdomen is imperative, seeking the presence of an abdominal bruit (renovascular disease or renal artery stenosis, primary or in association with Williams syndrome, neurofibromatosis, fibromuscular dysplasia, or arteritis) or the palpation of an abdominal mass (suggestive of Wilms tumor, neuroblastoma, pheochromocytoma, polycystic kidney disease or hydro-nephrosis).

A neurologic examination will look for evidence of raised intracranial pressure, hypertensive encephalopathy or neurologic deficits secondary to hypertension-induced vascular events.

2- Search for Associated Risk Factors and Co-Morbidity
Body mass index should be calculated and plotted on appropriate age and gender-specific charts when looking for the commonly associated obesity. When elevated it may suggest the presence of the metabolic syndrome, and when low it may suggest hyperthyroidism or pheochromocytoma.

The presence of acanthosis nigricans would also suggest the presence of the metabolic syndrome.

3- Search for Clinical Signs of Target-Organ Damage
Although these usually indicate longstanding hypertension, these changes may also be common, in patients with stage 1 hypertension if it has been present for a long time.7 31

Fundoscopic examination is imperative to look for changes of hypertensive retinopathy, cardiovascular examination for evidence of left ventricular hypertrophy and neurologic examination for evidence of neurological involvement.

Prognosis
The prognosis of a child with secondary hypertension is primarily determined by the nature of the underlying disease and its responsiveness to specific therapy.

Essential hypertension during childhood may track into adulthood. It has been shown that blood pressure measured in childhood predicts future blood pressure. Children with blood pressure above the 90th percentile have a 2.4-fold greater risk of having hypertension as adults and those having levels in the higher percentiles of the distribution curve maintain that position over time.32 Among adolescents with pre-hypertension, 14% develop hypertension within 2 years, resulting in an approximate incidence rate of 7% per year. Among adolescents having combined pre-hypertension and hypertension, 68% of boys and 43% of girls were found to develop pre-hypertension or hypertension 2 years later.33 In addition, nearly half of hypertensive adults were found to have had a blood pressure >90th percentile as children and 48% and 41% of young hypertensive adult have a history of elevated childhood systolic and diastolic blood pressures respectively.34 Although this blood pressure tracking pattern may vary by race, weight does not seem to affect it significantly.35 36 A systematic review and analysis of 50 cohort studies have also confirmed significant blood pressure tracking from childhood into adulthood, with that tracking increasing with baseline age and decreasing with the length of follow-up period. Because of this tracking from childhood into adulthood, early intervention is even more important.37 As in some recent studies the childhood systolic blood pressure values predictive of future hypertension in adults were well below childhood blood pressure levels presently considered to be high risk, the question now raised is whether it is the 95th percentile or the 90th percentile for blood pressure in childhood that adequately captures high risk blood pressure.38

Sustained hypertension results in albuminuria, hypertensive retinopathy, as well as increased intimal and medial thickness in blood vessels including the cerebral circulation. Microalbuminuria predicts progressive deterioration of
renal function and an increased risk of cardiovascular events in adults. In children with essential hypertension, the treatment of microalbuminuria with angiotensin converting enzyme inhibitors or angiotensin-receptor blockers is associated with regression of left ventricular hypertrophy.\textsuperscript{39} Despite the absence of longitudinal long-term data to assess outcome risk among adolescents with hypertension, data on surrogate markers of vascular injury indicate that vascular abnormality does occur even in the young.\textsuperscript{40} Structural changes in forearm vessels of obese adolescents with hypertension are present and a significant correlation exists between peripheral vascular resistance and insulin resistance.\textsuperscript{41} Carotid artery intimal medial thickness, assessed by ultrasound, is greater in young adults who had had multiple risk factors since childhood and also occurs in hypertensive adolescents.\textsuperscript{42,45} Digital retinal photographs measuring retinal arteriolar caliber in children has shown that those in the highest quartile of blood pressure have significantly narrower retinal arterioles than those with lower blood pressure, suggesting that higher blood pressure in childhood is associated with alteration in the microvasculature.\textsuperscript{46} Cognitive function has also recently been shown to be adversely affected by elevated blood pressure in childhood.\textsuperscript{47,48}

There is also a correlation between early childhood hypertension and early atherosclerosis. In a study based on autopsies of hypertensive adolescents who had suffered accidental death, vessel injury was detectable and there was a relationship between early aortic and coronary atherosclerotic lesions and cardiovascular risk factors, including hypertension, hyperlipidaemia, and smoking exposure.\textsuperscript{49-51} Studies in adult patients have shown that the treatment of mild to moderate hypertension decreases the risk of stroke and coronary heart disease.\textsuperscript{52} Children who are obese have approximately a 3-fold higher risk for hypertension than children who are not obese.

Increased left ventricular mass and diastolic dysfunction also occur, with, as many as 41% of children and adolescents with hypertension found to have left ventricular hypertrophy.\textsuperscript{40,53-55} There is a relationship between blood pressure and cardiac size, with left ventricular size increasing with increasing percentiles of blood pressure, suggesting a continuous rather than a threshold effect.\textsuperscript{56,57} Among children and adolescents with primary hypertension, the presence of obesity was associated with marked left ventricular hypertrophy.\textsuperscript{40}

There is a significant correlation between blood pressure and insulin levels measured during fasting in grade-school children and adolescents.\textsuperscript{58,59,60,61} Higher insulin levels have been noted in obese grade-school children and adolescents, associated with sensitivity to sodium and increased vascular reactivity.\textsuperscript{41,62,63} Structural changes have been found in forearm vessels of obese hypertensive adolescents and a significant correlation has been confirmed between peripheral vascular resistance and insulin resistance.\textsuperscript{41}

**Conclusion**

Although the prevalence of hypertension is lower in children and adolescents than in adults, increasing evidence indicates that essential hypertension begins to develop during the first two decades of life.\textsuperscript{26} Since even a small decrease in blood pressure can have substantial effects on hypertension-related morbidity and mortality, greater attention to blood pressure early in life may ultimately lead to considerable improvements in cardiovascular health.\textsuperscript{64,65}

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