CLINICAL PRACTICE

Caren G. Solomon, M.D., M.P.H., *Editor*

The Child or Adolescent with Elevated Blood Pressure

Julie R. Ingelfinger, M.D.

This Journal *feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the author's clinical recommendations.*

This article was updated on June 27, 2014, at NEJM.org.

N Engl J Med 2014;370:2316-25.
DOI: 10.1056/NEJMcp1001120

A 13-year-old boy visits his pediatrician because his school football team requires medical clearance before the start of the season. On physical examination, his weight is 72 kg (above the 99th percentile for age and sex) and his height is 155 cm (the 50th percentile); his body-mass index (the weight in kilograms divided by the square of the height in meters) is 30 (above the 99th percentile). His blood pressure is 134/77 mm Hg (the 99th percentile for systolic blood pressure and the 90th percentile for diastolic blood pressure), and his heart rate is 70 beats per minute. The serum creatinine level is 0.7 mg per deciliter (62 μmol per liter), and the urinalysis is normal. He is otherwise healthy and does not report any symptoms. His father has hypertension and type 2 diabetes. How should this case be further evaluated and treated?

THE CLINICAL PROBLEM

An audio version of this article is available at NEJM.org

The prevalence of elevated blood pressure among children and adolescents has been increasing worldwide in concert with the marked increase in the prevalence of obesity among the young.[1-3] Yet the best way to identify hypertension and the youth who are at greatest risk for hypertension is still debated. The most recent normative blood-pressure data on infants, children, and adolescents in the United States are from the fourth report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents[4] (hereinafter called the working group), which was published in 2004. The report presented a reclassification of blood-pressure levels and introduced the concept of prehypertension in children and adolescents, just as prehypertension was added as a category for adults in the 2003 report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure 7 (JNC 7).[5] The subsequent version of that report, JNC 8, which was released recently, still includes this category.[6] A person's blood pressure often follows a given centile over time; this phenomenon is called "tracking."[7-10] The working group thought that by changing the definition of early hypertension, awareness about hypertension would increase, with resultant better efforts at intervention, prevention, or both.[4]

Blood-pressure norms for children and adolescents (and associated cutoff points for prehypertension and hypertension) vary according to percentiles for age and height.[4,11-13] U.S. norms were determined on the basis of data on more than 60,000 children, including data from the most recent working group update, which added information from the 1999–2000 National Health and Nutrition Examination Survey.[4] For each year of age (through age 17), the working group tables[4] list the 50th, 90th, 95th, and 99th percentiles for systolic and diastolic blood pressure for children who are at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles for height (see

KEY CLINICAL POINTS

ELEVATED BLOOD PRESSURE IN A CHILD OR ADOLESCENT

- The prevalence of elevated blood pressure among children and adolescents has increased in concert with the marked increase in obesity among the young.
- Blood-pressure norms (and associated cutoff points for prehypertension and hypertension) for children and adolescents vary according to percentiles for age and height.
- The evaluation of elevated blood pressure in children and adolescents is designed to detect secondary hypertension, which may be curable.
- Management generally starts with nonpharmacologic therapy, followed by pharmacotherapy if the former approach is not successful; however, pharmacotherapy is initiated early if hypertension is severe or if there are concomitant conditions such as diabetes mellitus.
- Sustained hypertension in the young may be associated with end-organ damage.
- Available data suggest that therapy to lower blood pressure can reverse end-organ damage.

the Supplementary Appendix, available with the full text of this article at NEJM.org). Since some studies[14,15] have shown substantial underrecognition of elevated blood pressure in children in routine office practice, simplified versions of these tables, though not validated, have been developed to help clinicians identify children and adolescents at risk (Table 1, and www.pedhtn.org/BPLimitsChart0112.pdf).[11-13]

Hypertension is diagnosed in a child or adolescent if the mean systolic blood pressure or diastolic blood pressure is above the 95th percentile for sex, age, and height on three or more occasions. Prehypertension is defined as a mean systolic or diastolic blood pressure at or above the 90th percentile but below the 95th percentile (Table 2) or blood pressure of 120/80 mm Hg or greater, even if the blood pressure is at or below the 90th percentile.[4] Stage 1 hypertension is defined as blood pressure between the 95th and 99th percentile plus 5 mm Hg, and stage 2 hypertension is defined as blood pressure above the 99th percentile plus 5 mm Hg.

In a study involving three blood-pressure measurements in schoolchildren in Houston who were 11 to 17 years of age, 19% of the children had elevated blood pressure (15.7% had prehypertension, and 3.2% had hypertension).[16] Elevated blood pressure is more common among children who are overweight or obese than among children of normal weight.[11,17,18] A study comparing blood-pressure levels in children and adolescents in several countries[19] showed rates of elevated blood pressure as high as 17.3% in Brazil, 12.3 to 15.1% in Greece, and 13.8% in the United States. Available data suggest that if elevated blood pressure is defined as blood pressure of more than 120/80 mm Hg, as many as 15% of teens have this condition.[20]

The usefulness of identifying children who have elevated blood pressure has been questioned.[20,21] However, data suggest that end-organ damage is present at the time of diagnosis in a substantial number of children with this condition. For example, studies indicate that left ventricular hypertrophy is present in up to 40% of adolescents who have recently received a diagnosis of hypertension.[15,22] Increased rates of death, premature heart failure, coronary artery disease, and vascular stiffness among persons younger than 55 years of age have been associated with elevated blood pressure in childhood and adolescence.[23-26]

STRATEGIES AND EVIDENCE

EVALUATION

Many pediatricians' offices, clinics, and hospitals use oscillometric devices rather than manual sphygmomanometers to measure blood pressure, yet the working group norms are derived from measurements obtained with the latter. Oscillometric devices measure oscillations in the arterial wall and then derive systolic and diastolic blood-pressure levels with the use of proprietary

Table 1. Blood-Pressure Thresholds Indicating the Need for Further Evaluation, Intervention, or Both.*

Years of Age	Boys†		Girls†		Boys and Girls‡	
	SBP	DBP	SBP	DBP	SBP	DBP
	mm Hg					
3	100	59	100	61	≥100	>60
4	102	62	101	64	≥100	>60
5	104	65	103	66	≥100	>60
6	105	68	104	68	≥105	>70
7	106	70	106	69	≥105	>70
8	107	71	108	71	≥105	>70
9	109	72	110	72	≥110	>75
10	111	73	112	73	≥110	>75
11	113	74	114	74	≥110	>75
12	115	74	116	75	≥115	>75
13	117	75	117	76	≥115	>75
14	120	75	119	77	≥115	>75
15	120	76	120	78	≥120	>80
16	120	78	120	78	≥120	>80
17	120	80	120	78	≥120	>80
≥18	120	80	120	80	≥120	>80

* The threshold for further evaluation or intervention is based on cutoff points for hypertension from the fourth report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.[4] DBP denotes diastolic blood pressure, and SBP systolic blood pressure.
† Data are from Kaelber and Pickett.[11]
‡ Data are from Mitchell et al.[13]

algorithms.[27] These devices tend to overestimate the systolic blood-pressure level, although occasionally they may underestimate it. If blood-pressure levels are found to be elevated with the use of an oscillometric device, manual measurements should be obtained with an appropriate-sized cuff. Generally three blood-pressure measurements are obtained during each encounter, and the average of the three measurements is calculated; high readings from three separate encounters are required to confirm hypertension, unless the blood pressure is extremely elevated, in which case rapid evaluation is indicated.[4]

Ambulatory blood-pressure monitoring is indicated if it is unclear whether the blood pressure is elevated most of the time (and if so, the magnitude of elevation) or whether the patient has "white-coat" hypertension (elevated blood pressure in the clinician's office alone) or "masked" hypertension (normal blood pressure in the clinician's office but elevated blood pressure elsewhere).[28] The working group recommends considering ambulatory blood-pressure monitoring in these circumstances, as well as in patients with diabetes, chronic kidney disease, episodic hypertension, or autonomic dysfunction.[4] Studies conducted at referral clinics for evaluation of hypertension in children and adolescents have indicated that as many as 30 to 40% of children referred for evaluation of elevated blood pressure in a clinical setting may actually have white-coat hypertension.[29]

The extent of an evaluation in a child with hypertension should be guided by the severity of the elevation in blood pressure and the age of the child (Table 2).[4] The younger the child, the more likely it is that a definable cause will be identified for the elevation in blood pressure. Among children older than 10 years of age, primary hypertension is far more likely than secondary hypertension, particularly if the patient is overweight or obese, has a family history of hypertension, or both.[29] The evaluation should include ascertainment of the patient's medical history, prescribed medications, family history, and risk factors, including diet, sleep patterns, and activity level. Stimulants for the treatment of attention-deficit disorder may increase blood pressure, although data indicate that the increase is generally 5 mm Hg or less.[30] Clinicians should ask about the use of other agents that may increase blood pressure (e.g., pseudoephedrine), as well as about substance abuse and smoking habits. Physical examination should focus on signs of an underlying condition causing hypertension and on evidence of target-organ damage. Blood pressure should be measured in the upper and lower extremities to screen for coarctation, and these measurements should be obtained while the patient is seated and while he or she is in recumbent and standing positions, to rule out postural changes in blood pressure. Table 3 summarizes additional evaluations recommended by the Working Group on High Blood Pressure Control in Children and Adolescents.[4,26]

Evaluation of hypertension in children and adolescents is generally phased. In addition to a careful history taking and physical examination, a phase 1 evaluation to identify or rule out common causes of secondary hypertension is recommended in patients with blood pressure that is

Table 2. Classifications of Blood Pressure and Therapeutic Approaches.*

Systolic or Diastolic Blood Pressure†	Classification	Therapeutic Approach		
		Recheck Blood Pressure	Nonpharmacologic Therapy	Pharmacologic Therapy
<90th percentile	Normal blood pressure	At next scheduled physical examination	Healthy diet, physical activity, and sleep	None
90th to <95th percentile, or if blood pressure exceeds 120/80 mm Hg, even if it is <90th or <95th percentile	Prehypertension	In 6 mo	Counseling regarding weight management if patient is overweight or obese; physical-activity program and other diet management‡	None unless there is a clinical indication (diabetes, chronic kidney disease, left ventricular hypertrophy, or heart failure)
95th to 99th percentile plus 5 mm Hg	Stage 1 hypertension	In 1–2 wk, and sooner if patient has symptoms; if blood pressure is persistently elevated on two further occasions, initiate formal evaluation or refer within 1 mo	Counseling regarding weight management if patient is overweight or obese; physical-activity program and other diet management	Initiate according to blood-pressure level and presence of symptomatic hypertension, secondary hypertension, evidence of target-organ damage, or diabetes
>99th percentile plus 5 mm Hg	Stage 2 hypertension	Evaluate or refer within 1 week; refer immediately if patient has symptoms	Counseling regarding weight management if patient is overweight or obese; physical-activity program and other diet management	Initiate; more than one agent may be needed

* Adapted from the fourth report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.[4]

† Percentiles listed are based on blood pressure as measured on at least three separate occasions and determined according to the patient's age, height, and sex.

‡ Diet management may be facilitated by consultation with a licensed or registered nutritionist. A DASH (Dietary Approaches to Stop Hypertension) diet may be useful.

persistently at or above the 95th percentile and in patients with diabetes, cardiac disease, and other chronic conditions if the blood pressure is above the 90th percentile. This evaluation includes basic laboratory tests (measurement of levels of blood urea nitrogen, creatinine, and electrolytes; a complete blood count; and a urinalysis and urine culture) and renal ultrasonography to assess for renal scarring, disparate kidney size, and congenital anomalies.[4] About 80% of cases of secondary hypertension in children are attributed to renal disease, and another 10% are attributed to renovascular disease.

Left ventricular mass should also be assessed; the interpretation must consider the patient's height, body-surface area, and level of fitness.[15,25,31,32] In a study involving patients 5 to 18 years of age,[33] the left-ventricular-mass index (a height-adjusted index) was significantly higher in those with ambulatory blood-pressure readings in the hypertensive and prehypertensive range than in normotensive patients.[33]

A detailed eye examination is also informative in the evaluation of pediatric hypertension, since findings regarding the presence or absence of hypertensive retinopathy will help in therapeutic decision making. Arteriolar changes may be seen early in children with hypertension. In a cross-sectional study involving assessment of retinal diameter in two population-based cohorts of healthy schoolchildren 6 to 8 years of age (one in Australia and one in Singapore),[34] children in the higher blood-pressure quartiles had significantly greater arteriolar narrowing than did those in lower quartiles.

Limited data have indicated an increased prevalence of learning disabilities among children with mild-to-moderate hypertension, as compared with

Table 3. Continued Evaluation for Pediatric Hypertension.*

Procedure or Examination	Target Population	Purpose of Test
Evaluation for coexisting condition: fasting lipid panel, fasting blood glucose	Overweight children with blood pressure at 90th to 94th percentile; all patients with blood pressure at ≥95th percentile; children with chronic kidney disease, family history of hypertension, or cardiovascular disease	Identify hyperlipidemia and metabolic abnormalities
Evaluation for target-organ damage		
Echocardiography	Patients with risk factors for a coexisting condition and blood pressure at 90th–94th percentile; all patients with blood pressure at >95th percentile	Identify left ventricular hypertrophy and other indicators of cardiac involvement
Retinal examination	Patients with risk factors for a coexisting condition and blood pressure at 90th–94th percentile; all patients with blood pressure at >95th percentile	Identify retinal changes
Additional evaluation as indicated		
Ambulatory blood-pressure monitoring	Patients in whom white-coat hypertension is suspected and patients in whom detection of pattern of elevation would be helpful	Identify white-coat hypertension or abnormal diurnal blood-pressure pattern
Determination of plasma renin activity or level (and plasma aldosterone level)	Young children with stage 1 hypertension and children and adolescents with stage 2 hypertension	Identify low-renin hypertension, possible mineralocorticoid-mediated hypertension; identify high renin level that suggests renovascular disease; identify positive family history of hypertension
Renovascular imaging: isotopic scintigraphy (renal scan), magnetic resonance angiography, duplex Doppler flow studies, three-dimensional computed tomography, digital-subtraction angiography, or classic arteriography	Young children with stage 1 hypertension and children and adolescents with stage 2 hypertension	Identify renovascular disease
Plasma and urinary steroid levels	Young children with stage 1 hypertension and children and adolescents with stage 2 hypertension	Identify steroid-mediated hypertension
Plasma and urinary catecholamines	Young children with stage 1 hypertension and children and adolescents with stage 2 hypertension	Identify catecholamine-mediated hypertension

* Adapted from the fourth report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.[4]

controls.[35] A multicenter study is currently ongoing to confirm these findings.[36] Other data have indicated increased carotid intima–media thickness[37] (which is considered to be a marker of atherosclerosis in adults) in children with hypertension, as compared with controls. However, neither neurocognitive testing nor determination of carotid intima–media thickness is included in current guidelines for routine clinical assessment.

TREATMENT OPTIONS

Treatment for pediatric hypertension is guided by the evaluation. Discussion of the management of various causes of secondary hypertension is beyond the scope of this review. If the evaluation suggests that the patient has primary hypertension, nonpharmacologic therapy is generally the first approach.

Nonpharmacologic Therapy

Lifestyle changes are recommended for children with prehypertension or stage 1 hypertension.[4,38-42] These approaches include a program of dynamic exercise (i.e., exercise that involves substantial and recurrent body movement, such as bicycling or running); a balanced diet with a high intake of fruits, vegetables, and low-fat dairy products, as well as a reduction in dietary sodium; a weight-reduction program in patients who are overweight; and reinforcement of adherence to these practices.

Several studies involving children and adolescents have suggested that successful weight loss is effective in decreasing blood-pressure levels. For example, a randomized trial involving obese adolescents showed that a family-based weight-loss program (with focused family meetings about weight, exercise, and nutrition), as compared with usual care, led to more weight loss and greater improvements in blood-pressure and metabolic levels.[39] In a randomized trial comparing 12-week regimens of exercise, diet, and a combination of these approaches in preadolescent children who were overweight,[43] all the groups had reductions in weight and in diastolic blood pressure at 12 weeks, and there were no significant differences among the groups. Another controlled trial of a behavioral nutritional program involving the DASH (Dietary Approaches to Stop Hypertension) diet in hypertensive teens[42] showed a greater decrease in systolic (although not diastolic) blood pressure in the DASH-diet group than in controls at the 3-month follow-up.[42]

However, effecting such changes is often difficult. The inclusion of family participation appears to be useful, if not essential, particularly if the child needs to lose weight.[39]

It is uncertain how much exercise should be recommended and how best to encourage participation.[44] Adherence to an exercise regimen appears to be improved with frequent visits to and feedback from a clinician, physical-fitness counselor, or nutritionist, as well as with the use of ancillary devices such as pedometers; in cross-sectional studies, more steps walked, as measured by pedometer, are correlated with lower blood pressures.[45]

Pharmacotherapy

If blood pressure does not improve with lifestyle changes, or if concerted efforts to encourage lifestyle modification are not successful, medication may be indicated.[4,46-50] Medication should be initiated if there are symptoms or coexisting health conditions or if there is an identified secondary cause of hypertension or evidence of end-organ damage in children or adolescents with stage 1 hypertension. In addition, drug therapy should be initiated routinely in young people with stage 2 hypertension.[4]

There is some evidence that target-organ damage may regress with the use of pharmacotherapy.[51,52] One study involving children and adolescents who were assessed after 1 year of therapy showed significant reductions from baseline in the left-ventricular-mass index, the prevalence of left ventricular hypertrophy, and the carotid intima–media thickness.[51] Another small study indicated that left ventricular hypertrophy regressed after a year of therapy with an angiotensin-converting–enzyme (ACE) inhibitor.[52]

The number of antihypertensive agents that have Food and Drug Administration (FDA)–approved pediatric labeling has increased markedly since passage of the FDA Modernization Act of 1997, which underscored the need to evaluate medications used in children for which there were no specific pediatric indications. Since then, many antihypertensive agents have been studied in children; this has led to better information about pharmacokinetics, adverse events, and appropriate dosing. A list of such agents is provided in Table 4.

There is no consensus regarding the best initial therapy for hypertension in children and adolescents; comparative trials are lacking in the pediatric population. A survey of pediatric nephrologists indicated that 47% considered ACE inhibitors to be first-line therapy, 37% chose calcium-channel blockers, 15.3% chose diuretics, and 6.6% chose beta-blockers (some chose more than one medication as a first-line agent).[53] JNC 7[5] favored the use of thiazide-type diuretics in adults, and JNC 8[6] suggests four potential first-line classes of antihypertensive medication in adults. However, data to inform the use of thiazides or other medication classes for treating pediatric hypertension are limited, and agents in several different classes are considered acceptable choices.[50]

AREAS OF UNCERTAINTY

Longitudinal data regarding outcomes in children and adolescents with hypertension are sparse. Data also are lacking from clinical trials regarding long-term effects of lifestyle and pharmacologic interventions in patients in this age group. Achieving and maintaining lifestyle changes and adherence to medication are challenging, particularly in adolescents, and effective strategies to improve adherence remain uncertain.

GUIDELINES

The National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents last updated its recommendations in 2004.[4] Newer guidelines from the European Society for Hypertension,[54] which were issued in the fall of 2009, are similar to the U.S. working group recommendations.[4] The present recommendations are con-

Table 4. Selected Oral Medications for Hypertension in Children and Adolescents.*

Class and Agent	Initial Dose	Maximum Dose†	Common Adverse Events
ACE inhibitor			
Captopril‡	0.3–0.5 mg/kg/dose	6 mg/kg/day (to 450 mg/day)	Hyperkalemia, cough, dysgeusia, complete blood count, abnormalities, angioedema, ACE fetopathy
Enalapril‡	0.08 mg/kg/day	0.6 mg/kg/day (to 40 mg)	Hyperkalemia, cough, dysgeusia, complete blood count, abnormalities, angioedema, ACE fetopathy
Lisinopril‡	0.07 mg/kg/day (to 5 mg)	0.6 mg/kg/day (to 40 mg)	Hyperkalemia, cough, dysgeusia, complete blood count, abnormalities, angioedema, ACE fetopathy
Calcium-channel blocker			
Amlodipine‡	0.06 mg/kg/day	0.3 mg/kg/day (to 10 mg/day)	Reflex tachycardia, edema
Isradipine‡	0.05–0.15 mg/kg/dose 3 or 4 times/day	0.8 mg/kg/day (to 20 mg/day)	Reflex tachycardia, edema
Extended-release nifedipine	0.25–0.5 mg/kg/day	3 mg/kg/day (to 120 mg/day)	Reflex tachycardia, edema
Diuretic			
Amiloride	0.4–0.625 mg/kg/day	20 mg/day	Hypokalemia, hypercholesterolemia, dysglycemia
Chlorthalidone	0.3 mg/kg/day	2 mg/kg/day (to 50 mg/day)	Hypokalemia, hypercholesterolemia, dysglycemia
Furosemide§	0.5–2 mg/kg/dose 1 or 2 times/day	6 mg/kg/day	Hypokalemia, hypercholesterolemia, dysglycemia
Hydrochlorothiazide	0.5–1 mg/kg/day	3 mg/kg/day (to 50 mg/day)	Hypokalemia, hypercholesterolemia, dysglycemia
Beta-adrenergic antagonist			
Atenolol‡	0.5–1 mg/kg/day	2 mg/kg/day (to 100 mg/day)	Bradycardia, impaired sports performance; avoid in patients with asthma or heart failure
Metoprolol	1–2 mg/kg/day	6 mg/kg/day (to 200 mg/day)	Bradycardia, impaired sports performance; avoid in patients with asthma or heart failure
Propranolol§	1 mg/kg/day	6 mg/kg/day (to 640 mg/day)	Bradycardia, impaired sports performance; avoid in patients with asthma or heart failure
Vasodilator			
Hydralazine	0.75 mg/kg/day in 3 or 4 divided doses	7.5 mg/kg/day (200 mg/day)	Tachycardia, edema
Minoxidil	In children <12 yr: 0.2 mg/kg/day; in children ≥12 yr: 5 mg/day	In children <12 yr: 50 mg/day; in children ≥12 yr: 100 mg/day	Tachycardia, edema, hirsutism

Table 4. (Continued.)

Class and Agent	Initial Dose	Maximum Dose†	Common Adverse Events
Angiotensin-receptor blocker			
Losartan‡	0.7 mg/kg/day (to 50 mg/day)	1.4 mg/kg/day (to 100 mg/day)	Hyperkalemia; cough, (though less commonly than with ACE inhibitors); contraindicated in pregnancy
Valsartan‡	If patient <6 yr: 5–10 mg/day; if patient 6–17 yr: 1.3 mg/kg/day up to 40 mg total	If patient <6 yr: 80 mg/day; if patient 6–17 yr: 2.7 mg/kg/day up to 160 mg total	Hyperkalemia, cough (though less commonly than with ACE inhibitors); contraindicated in pregnancy
Alpha- and beta-adrenergic antagonists			
Carvedilol‡	0.1 mg/kg/dose (to 6.25 mg/day)	0.5 mg/kg/dose (to 25 mg) twice daily	Dizziness, depression, dry eyes, wheezing, bradycardia, gastrointestinal side effects, lower-extremity edema
Labetalol‡	1–3 mg/kg/day	1200 mg/day	Dizziness, depression, dry eyes, wheezing, bradycardia, gastrointestinal side effects, lower-extremity edema
Centrally acting alpha agonist: clonidine‡	5–20 μg/kg/day	25 μg/kg/day (to 0.9 mg/day)	Sedation
Aldosterone receptor antagonist			
Eplerenone	25 mg/day	100 mg/day	Hyperkalemia, dizziness, hypercholesterolemia
Spironolactone	1 mg/kg/day	3.3 mg/kg/day (to 100 mg/day)	Hyperkalemia, dizziness, gynecomastia

* Adapted from the fourth report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.[4] The order of presentation of classes is based on a survey of pediatric nephrologists.[53] However, as experience grows with the use of angiotensin-receptor blockers and aldosterone-receptor antagonists, practice will probably change. This is not a comprehensive listing of pediatric doses. ACE denotes angiotensin-converting enzyme.
† The maximum adult dose for any medication should not be exceeded.
‡ Information on how to prepare stable extemporaneous suspension is available.
§ This drug is available as a commercially supplied oral solution that is approved by the Food and Drug Administration.

sistent with these guidelines. In addition, the European guidelines provide some normative values for ambulatory blood-pressure monitoring.[54] A recently released U.S. Preventive Services Task Force report[21] concluded that "current evidence is insufficient to assess the balance of benefits and harms of screening for primary hypertension in asymptomatic children and adolescents to prevent subsequent cardiovascular disease in childhood or adulthood." However, some clinicians, specialists, and researchers have criticized the report[22,55] as ignoring available data suggesting that end-organ damage may be reversed with therapy. Furthermore, although the report considers harms associated with blood-pressure measurement, children with undetected hypertension may have complications that include hypertensive crisis, which the report does not consider.[21]

CONCLUSIONS AND RECOMMENDATIONS

The 13-year-old boy described in the vignette has elevated blood pressure that may be categorized as stage 1 hypertension, and he is also obese. He probably has primary hypertension, but he should undergo a careful history taking and physical examination (including a retinal examination), basic laboratory tests, echocardiography, and renal ultrasonography to screen for underlying renal disease. I would first institute a trial of lifestyle changes, including a low-salt, high-potassium, weight-control diet and exercise, and I would

make a strong effort to enlist the support of his family, teachers, and other adults. I would recommend frequent follow-up to monitor his weight, fitness, and blood pressure, and I would encourage a program of dynamic exercise. If his blood pressure did not decrease to nonhypertensive levels after 6 to 12 months of nonpharmacologic therapy, I would consider instituting pharmacotherapy.[4,53] In the absence of a sufficient number of head-to-head medication trials involving children and adolescents to guide the choice of therapy, any of several classes of medication studied in children would be acceptable. I would probably start with an ACE inhibitor, provided that there were no contraindications, since it is unlikely that this class of medications would affect his running or endurance.

No potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

REFERENCES

1. Lo JC, Sinaiko A, Chandra M, et al. Prehypertension and hypertension in community-based pediatric practice. Pediatrics 2013;131(2):e415-e424.
2. Flynn JT. The changing face of pediatric hypertension in the era of the childhood obesity epidemic. Pediatr Nephrol 2013;28:1059-66.
3. Chockalingam A, Campbell NR, Fodor JG. Worldwide epidemic of hypertension. Can J Cardiol 2006;22:553-5.
4. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics 2004;114:Suppl:555-76.
5. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure: the JNC 7 report. JAMA 2003;289:2560-72. [Erratum, JAMA 2003; 290:197.]
6. James PA, Oparil S, Carter BL, et al. 2014 Evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 2014;311:507-20.
7. Bao W, Threefoot SA, Srinivasan SR, Berenson GS. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: the Bogalusa Heart Study. Am J Hypertens 1995;8:657-65.
8. Lauer RM, Clarke WR. Childhood risk factors for high adult blood pressure: the Muscatine Study. Pediatrics 1989;84:633-41.
9. Carrico RJ, Sun SS, Sima AP, Rosner B. The predictive value of childhood blood pressure values for adult elevated blood pressure. Open J Pediatr 2013;3:116-26.
10. Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. Circulation 2008;117:3171-80.
11. Kaelber DC, Pickett F. Simple table to identify children and adolescents needing further evaluation of blood pressure. Pediatrics 2009;123(6):e972-e974.
12. McLaughlin D, Hayes JR, Kelleher K. Office-based interventions for recognizing abnormal pediatric blood pressures. Clin Pediatr (Phila) 2010;49:355-62.
13. Mitchell CK, Theriot JA, Sayat JG, Muchant DG, Franco SM. A simplified table improves the recognition of paediatric hypertension. J Paediatr Child Health 2011;47:22-6.
14. Hansen ML, Gunn PW, Kaelber DC. Underdiagnosis of hypertension in children and adolescents. JAMA 2007;298: 874-9.
15. 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.
16. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. J Pediatr 2007; 150:640-4.
17. Ramos E, Barros H. Prevalence of hypertension in 13-year-old adolescents in Porto, Portugal. Rev Port Cardiol 2005; 24:1075-87.
18. Salvadori M, Sontrop JM, Garg AX, et al. Elevated blood pressure in relation to overweight and obesity among children in a rural Canadian community. Pediatrics 2008;122(4):e821-e827.
19. Feber J, Ahmed M. Hypertension in children: new trends and challenges. Clin Sci (Lond) 2010;119:151-61.
20. Thompson M, Dana T, Bougatsos C, Blazina I, Norris SL. Screening for hypertension in children and adolescents to prevent cardiovascular disease. Pediatrics 2013;131:490-525.
21. Moyer VA. Screening for primary hypertension in children and adolescents: U.S. Preventive Services Task Force recommendation statement. Pediatrics 2013;132: 907-14.
22. McNiece KL, Gupta-Malhotra M, Samuels J, 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.
23. Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. N Engl J Med 2010;362:485-93.
24. Bibbins-Domingo K, Pletcher MJ, Lin F, et al. Racial differences in incident heart failure among young adults. N Engl J Med 2009;360:1179-90.
25. Erlingsdottir A, Indridason OS, Thorvaldsson O, Edvardsson VO. Blood pressure in children and target-organ damage later in life. Pediatr Nephrol 2010;25:323-8.
26. Li S, Chen W, Srinivasan SR, Berenson GS. Childhood blood pressure as a predictor of arterial stiffness in young adults: the Bogalusa Heart Study. Hypertension 2004;43:541-6.
27. Flynn JT, Alderman MH. Characteristics of children with primary hypertension seen at a referral center. Pediatr Nephrol 2005;20:961-6.
28. Butani L, Morgenstern BZ. Are pitfalls of oxcillometric blood pressure measurements preventable in children? Pediatr Nephrol 2003;18:313-8.
29. Flynn JT, Urbina EM. Pediatric ambulatory blood pressure monitoring: indications and interpretations. J Clin Hypertens (Greenwich) 2012;14:372-82.
30. Hammerness PG, Perrin JM, Shelley-Abrahamson R, Wilens TE. Cardiovascular risk of stimulant treatment in pediatric attention-deficit/hyperactivity disorder: update and clinical recommendations. J Am Acad Child Adolesc Psychiatry 2011;50: 978-90.
31. Gidding SS, Daniels SR, Kavey RE. Developing the 2011 Integrated Pediatric Guidelines for Cardiovascular Risk Reduction. Pediatrics 2012;129(5):e1311-e1319.
32. Urbina E, Alpert B, Flynn J, et al. Ambulatory blood pressure monitoring in children and adolescents: recommendations for standard assessment: a scientific statement from the American Heart Association Atherosclerosis, Hypertension, and Obesity in Youth Committee of the Council on Cardiovascular Disease in the Young and the Council for High Blood Pressure Research. Hypertension 2008;52: 433-51.
33. Stabouli S, Kotsis V, Rizos Z, et al. Left ventricular mass in normotensive, prehypertensive and hypertensive children

and adolescents. Pediatr Nephrol 2009;24:1545-51.
34. Mitchell P, Cheung N, de Haseth K, et al. Blood pressure and retinal arteriolar narrowing in children. Hypertension 2007;49:1156-62.
35. Adams HR, Szilagyi PG, Gebhardt L, Lande MB. Learning and attention problems among children with pediatric primary hypertension. Pediatrics 2010;126(6):e1425-e1429.
36. Lande MB, Adams HR, Kupferman JC, Hooper SR, Szilagyi PG, Batisky DL. A multicenter study of neurocognition in children with hypertension: methods, challenges, and solutions. J Am Soc Hypertens 2013;7:353-62.
37. Sorof JM, Alexandrov AV, Garami Z, et al. Carotid ultrasonography for detection of vascular abnormalities in hypertensive children. Pediatr Nephrol 2003;18:1020-4.
38. Holm JC, Gamborg M, Neland M, et al. Longitudinal changes in blood pressure during weight loss and regain of weight in obese boys and girls. J Hypertens 2012;30:368-74.
39. Kalarchian MA, Levine MD, Arslanian SA, et al. Family-based treatment of severe pediatric obesity: randomized, controlled trial. Pediatrics 2009;124:1060-8.
40. Appel LJ, Giles TD, Black HR, et al. ASH Position Paper: dietary approaches to lower blood pressure. J Clin Hypertens (Greenwich) 2009;11:358-68.
41. Günther AL, Liese AD, Bell RA, et al. Association between the dietary approaches to hypertension diet and hypertension in youth with diabetes mellitus. Hypertension 2009;53:6-12.
42. Couch SC, Saelens BE, Levin L, Dart K, Falciglia G, Daniels SR. The efficacy of a clinic-based behavioral nutrition intervention emphasizing a DASH-type diet for adolescents with elevated blood pressure. J Pediatr 2008;152:494-501.
43. Shalitin S, Ashkenazi-Hoffnung L, Yackobovitch-Gavan M, et al. Effects of a twelve-week randomized intervention of exercise and/or diet on weight loss and weight maintenance, and other metabolic parameters in obese preadolescent children. Horm Res 2009;72:287-301.
44. Fixler DE, Laird WP, Dana K. Usefulness of exercise stress testing for prediction of blood pressure trends. Pediatrics 1985;75:1071-5.
45. Schofield G, Schofield L, Hinckson EA, Mummery WK. Daily step counts and selected coronary heart disease risk factors in adolescent girls. J Sci Med Sport 2009;12:148-55.
46. Stabouli S, Papakatsika S, Kotsis V. The role of obesity, salt and exercise on blood pressure in children and adolescents. Expert Rev Cardiovasc Ther 2011;9:753-61.
47. McCambridge TM, Benjamin HJ, Brenner JS, et al. Athletic participation by children and adolescents who have systemic hypertension. Pediatrics 2010;125:1287-94.
48. Flynn JT, Daniels SR. Pharmacologic treatment of hypertension in children and adolescents. J Pediatr 2006;149:746-54.
49. Robinson RF, Nahata MC, Batisky DL, Mahan JD. Pharmacologic treatment of chronic pediatric hypertension. Paediatr Drugs 2005;7:27-40.
50. Ferguson MA, Flynn JT. Pharmacologic treatment of childhood hypertension. In: Flynn JT, Ingelfinger JR, Portman RJ, eds. Pediatric hypertension. 3rd ed. New York: Springer, 2013:539-55.
51. Litwin M, Niemirska A, Sladowska-Kozlowska J, et al. Regression of target organ damage in children and adolescents with primary hypertension. Pediatr Nephrol 2010;25:2489-99.
52. Seeman T, Gilík J, Vondrák K, et al. Regression of left-ventricular hypertrophy in children and adolescents with hypertension during ramipril monotherapy. Am J Hypertens 2007;20:990-6.
53. Woroniecki RP, Flynn JT. How are hypertensive children evaluated and managed? A survey of North American pediatric nephrologists. Pediatr Nephrol 2005;20:791-7.
54. Lurbe E, Cifkova R, Cruickshank JK, et al. Management of high blood pressure in children and adolescents: recommendations of the European Society of Hypertension. J Hypertens 2009;27:1719-42.
55. Daniels SR, Gidding SS. Blood pressure screening in children and adolescents: is the glass half empty or more than half full? JAMA Pediatr 2013;167:302-4.