Hypertension
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Educational Gap

Pediatric hypertension is on the rise, now affecting almost 5% of all children. Clinicians should be following the latest guidelines on management of pediatric hypertension, including recommendations to measure blood pressure at every visit in all children age 3 years and older and some at-risk children younger than age 3 years, as well as to employ pharmacologic therapy for some children.

Objectives

After completing this article, readers should be able to:

1. Define hypertension in children, and be familiar with the approach to the diagnosis of hypertension.
2. Recognize important signs and symptoms associated with hypertension and its sequelae, and formulate an appropriate differential when presented with a hypertensive child or adolescent.
3. Initiate an appropriate evaluation, and know when to refer to subspecialty care.
4. Prescribe both nonpharmacologic and pharmacologic antihypertensive therapy to hypertensive children, and be familiar with the various classes of antihypertensive medications available.

Case Study

Jennifer is a 12-year-old girl who plays field hockey and is in your office for a sports physical. She reports feeling well, denies any complaints, and has no significant past medical history. She is not taking any medications. Family history is reviewed and is significant only for grandparents on both sides of the family having hypertension (HTN) and a paternal grandfather who had a myocardial infarction at age 60 years and is still living. She is a straight A student and lives at home with her parents and 2 brothers, who are healthy. Review of systems is significant for achieving menarche several months earlier.

Physical examination shows both her height and weight to be at the 50th percentile. Blood pressure (BP) was 136/82 mm Hg initially in triage; repeat is 132/78 mm Hg by the same automated oscillometric device 5 minutes later. She is a healthy-appearing young girl who is comfortable and in no apparent distress. The rest of her physical examination is well within normal limits. You repeat her BP by manual auscultation and obtain a measurement of 128/77 mm Hg.

Introduction

Although once affecting only 1% of all children, pediatric HTN is on the rise, now affecting almost 5% of all children. One possible explanation for this striking increase in prevalence over the past several decades is the concurrent rise in pediatric obesity, which currently affects 17% of US children and adolescents. BP increases with increasing BMI, which explains the staggering 30% of obese children who are hypertensive. This significant increase makes it much more likely that clinicians will find themselves caring for hypertensive children, heightening the need for proper recognition, evaluation, and treatment in the primary care setting.

Definition

Pediatric HTN is defined as the sustained elevation of either the systolic or diastolic BP at or above the 95th percentile of BP for a child’s age, gender, and height percentile. Essential to this definition is the presence of sustained BP elevation, which is why all elevated BP
measurements should be confirmed by repeated measurements conducted by manual auscultation, with the average of all measurements used to determine the category of HTN. The severity of the elevation will dictate how many measurements are needed before diagnosis and evaluation. (1) In 2004, Pediatrics published updated gender, age, and height percentile-specific 50th, 90th, 95th, and 99th percentile systolic and diastolic BPs for children aged 1 to 17 years. (2) These normative values were compiled from more than 60,000 healthy children in the United States, based on their first auscultatory BP measurement obtained during screening, and should be used to classify children into one of the following BP categories:

1. Normal BP: Both systolic and diastolic BPs are less than the 90th percentile or less than 120/80 mm Hg, whichever is lower.
2. Prehypertension: Systolic or diastolic BP is between the 90th percentile and the 95th percentile, or between 120/80 mm Hg and the 95th percentile, if 120/80 mm Hg happens to be higher than the reported 90th percentile for the individual child based on his or her age, gender, and height percentile.
3. Stage I HTN: Systolic or diastolic BP between the 95th percentile and the 99th percentile + 5 mm Hg.
4. Stage II HTN: Systolic or diastolic BP above the 99th percentile + 5 mm Hg.

The Figure provides a graph of the 95th percentile of blood pressure for boys and girls of different ages and heights.

Adolescents and young adults age 18 to 21 years should be classified as follows (1):

1. Prehypertension: Systolic or diastolic BP ≥120/80 and ≤139/89 mm Hg
2. Stage I HTN: Systolic or diastolic BP ≥140/90 and ≤159/99 mm Hg
3. Stage II HTN: Systolic or diastolic BP ≥160/100 mm Hg

When to Screen for Hypertension

All children age 3 years and older should have their BP measured during each physician visit, whether the visit is for health supervision care, urgent care, or emergency care, at a minimum of once yearly. In addition, children younger than age 3 years should also have their BP measured at each visit if they have a comorbid condition that places them at increased risk for HTN (Table 1).

Particular attention should be given to children who have conditions such as diabetes mellitus, chronic kidney disease, a history of Kawasaki disease (with or without current coronary artery aneurysms), kidney or heart transplantation, chronic inflammatory diseases, human immunodeficiency virus infection, and nephrotic syndrome, because they are at increased cardiovascular risk. In addition to regular BP measurement, these children should have additional cardiovascular risk factor assessment conducted at health care encounters.

Any child with a BP measurement at or above the 90th percentile (or ≥120/80 mm Hg if this figure is >90th percentile for age) should have his or her BP remeasured at that visit. The average of three measurements obtained by manual auscultation should be recorded, and the child should be “staged” as defined above. This staging and the presence or absence of symptoms will dictate plans for future follow-up:

An Average Blood Pressure in the Prehypertensive Range

These children should be considered prehypertensive and should be followed closely because of their increased risk of developing sustained HTN. They should be counseled on weight management, if indicated, and should be given activity and the Cardiovascular Health Integrated Lifestyle Diet-1 recommendations (see “Treatment” section below). (1) Prehypertensive children should have a follow-up appointment in 6 months to reassess BP.

An Average Blood Pressure in the Range of Stage I Hypertension

If the child is asymptomatic, have him or her return for repeat BP measurements on two additional occasions, 1 to 2 weeks apart. If stage I HTN is confirmed by averaging all BP measurements obtained, perform evaluation within 1 month. If the child is symptomatic, more immediate referral to a pediatric HTN specialist for initiation of evaluation and treatment is indicated.

An Average Blood Pressure in the Range of Stage II Hypertension

If the child is asymptomatic, he or she should undergo evaluation and treatment within 1 week. If symptomatic, the child should be referred immediately to the emergency department or an inpatient facility for care.

Pediatric HTN is largely asymptomatic; however, children may present initially in hypertensive crisis with severely elevated BP and symptoms ranging from nausea and vomiting to ataxia, mental status changes, seizures, and coma, or with symptoms related to the underlying cause of their HTN. In addition, some children may experience anxiety during evaluations, which may cause elevated BPs that are in the hypertensive range; yet, when monitored in their home environment, the children have
BP measurements in the normal range. This phenomenon of “white coat” HTN can be diagnosed with a 24-hour ambulatory BP monitor that obtains many BP measurements taken in a child’s home environment. Children who manifest white coat HTN also should be considered at increased risk for the development of sustained HTN and therefore should be followed every 6 months. (3–5)

Proper Blood Pressure Measurement
To identify and diagnose a child with HTN, one must use proper technique when measuring BP. Proper technique begins with applying the correct size cuff to a child’s bare arm and ensuring that his or her arm, feet, and back are supported, with the cubital fossa positioned at heart level. To determine the correct cuff size, measure the cuff bladder (felt inside the outer packaging) to the child’s arm. The right size cuff will have a bladder width that is at least 40% of the child’s midarm circumference and a bladder length that encircles 80% to 100% of the midarm circumference. When in doubt, choose a larger cuff because a cuff that is too-small may result in artificially elevated BP.

After the child has been resting for 5 minutes:

1. Locate the child’s radial pulse, quickly inflate the sphygmomanometer to 60 mm Hg, then slowly continue to inflate in increments of 10 mm Hg until the pulse disappears.
2. Note the peak inflation level, which is the value at which the pulse disappears + 30 mm Hg.
3. Deflate the cuff, and after 30 seconds inflate the sphygmomanometer to the peak inflation level.
4. Deflate by 2 to 3 mm Hg/second to a level that is 10 mm Hg lower than the last Korotkoff sound (K5).
   a. Systolic BP = onset of Korotkoff sounds (K5).
   b. Diastolic BP = disappearance of Korotkoff sounds (K5).

All BP elevations (systolic or diastolic BP ≥90th percentile or ≥120/80 mm Hg) should be confirmed by this
technique, rather than by an automated device. Automated, or oscillometric, devices, while useful as screening tools, can provide inaccurate BP measurements because they do not measure BP directly, but instead estimate the systolic and diastolic BP based on the point of maximal oscillation (the mean intra-arterial pressure) during cuff deflation. The algorithms used to determine these values vary from device to device, leading to non-uniformity of measurement across devices. Devices that automatically inflate to 30 mm Hg above the previous reading can influence each subsequent BP reading.

These limitations, and the fact that the normative values that make up the reference tables were obtained via auscultation, form the basis for the recommendation that all BP elevations must be confirmed by manual auscultation.

Initial Evaluation

All children diagnosed as having HTN should undergo an evaluation to investigate for secondary causes of HTN. Although primary HTN is on the rise, and is the most common cause of HTN among adolescents, secondary HTN is common enough to warrant investigation, particularly in younger children and those with stage II HTN at presentation (Table 2).

The initial evaluation should start with a focused history and physical examination. In addition to obtaining a complete review of systems to help narrow the differential diagnosis (Table 3 below), particular attention should be paid to the past medical history (including birth history), current medications, family history, and social history.

When obtaining the past medical history, it is important to inquire about any previous diagnosis or treatment of HTN. Any recent discontinuation of antihypertensive medications, such as β-blockers and α-adrenergic agonists, can cause severe rebound HTN if discontinued abruptly. It is important also to determine if the child has any of the following comorbid conditions or syndromes associated with HTN:

**Comorbid Conditions:**
- Diabetes mellitus
- Thyroid disease
- Cushing syndrome
- Systemic lupus erythematosus
- Other rheumatologic disorder

** Syndromes:**
- Williams syndrome (associated with supravalvular aortic stenosis, midaortic syndrome, renal artery stenosis, renal anomalies)
- Turner syndrome (associated with coarctation of the aorta, renal anomalies, idiopathic HTN)
- Tuberous sclerosis (associated with coarctation of the aorta, renal artery stenosis, brain tumors)
- Neurofibromatosis (associated with essential and renovascular HTN)
- Polycystic kidney disease, both autosomal recessive and autosomal dominant variants

A previous history of urinary tract infections or unexplained fevers may suggest chronic pyelonephritis and renal cortical scars or reflux nephropathy. A recent or relatively remote streptococcal infection of the pharynx or skin, or exposure to enterohemorrhagic *Escherichia coli*, may indicate a resolving or resolved postinfectious glomerulonephritis or hemolytic uremic syndrome, respectively. Henoch-Schönlein purpura can be associated with persistent renal manifestations, including HTN, even after initial complete resolution of symptoms. Previous hospitalizations may reveal information on systemic illnesses, exposure to nephrotoxic medications, or evidence of renal injury. Recent injuries should be assessed, because renal or neurologic trauma can lead to HTN as well as associated pain.

Because prematurity and low birthweight are associated with decreased nephron endowment and HTN, and umbilical catheter placement can lead to renal artery
stenosis and renal vein thrombosis, a detailed birth history also should be obtained.

A thorough review of both prescribed and over-the-counter medications may reveal the following possible causes for elevated BP:

- Corticosteroids
- Decongestants/cold preparations
- Nonsteroidal anti-inflammatory medications
- Herbal medications/supplements
- Oral contraceptive pills
- Antihypertensive medications (recent discontinuation of these medications)
- β-Adrenergic agonists/theophylline
- Erythropoietin
- Cyclosporine/tacrolimus
- Attention deficit disorder medications

The family history can be helpful in determining the cause of HTN, particularly for children who have monogenic forms of HTN (such as Liddle syndrome, Gordon syndrome, and apparent mineralocorticoid excess) and renal disease, and can help also with risk stratification. As described in the recent Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, (1) a positive family history of coronary heart disease in a male relative (father, grandfather, sibling, or uncle) younger than 55 years or in a female relative (mother, grandmother, sibling, or aunt) younger than 65 years is an independent risk factor for having cardiovascular disease. This risk is inversely related to the age at the time of event. Children who have this family history should be considered at increased cardiovascular risk.

Social history should focus on the following: sexual activity (pregnancy, pre-eclampsia); diet (consumption of caffeine, licorice, sodium, nutritional supplements); smoking/drinking/illicit drug history (nicotine, cocaine, amphetamines, anabolic steroids, phencyclidine, methylenedioxymethamphetamine [“ecstasy”]); level of physical activity (obesity); sleep history (snoring, daytime somnolence, difficulty awakening, which may be suggestive of obstructive sleep apnea); and psychosocial history (stress, anxiety).

After eliciting a detailed history, the evaluation should then progress to a detailed physical examination, paying particularly close attention to findings suggestive of underlying causes (Table 4).

After the history and physical examination, all children should undergo a laboratory and imaging evaluation, the details of which are listed in Table 5. If the results of this initial evaluation are negative in an older child who has stage I HTN, particularly if the average BP is close to the 95th percentile, the child can be given a diagnosis of primary HTN. Younger children and those with more markedly elevated BP (stage II HTN) should undergo further testing if the initial evaluation is unrevealing to exclude secondary causes for HTN (Table 6).
Treatment
Once a child is diagnosed as having HTN and has undergone an evaluation, antihypertensive therapy should be initiated. This therapy should include guidance on lifestyle modification and nonpharmacologic therapy. All children should be counseled on the following heart-healthy lifestyle:

1. Weight loss if overweight
2. For children age 5 years or older: participate in at least 1 hour of moderate-to-vigorous exercise (eg, jogging, baseball) every day of the week, and vigorous activity (eg, running, singles tennis, soccer) on 3 days per week.

3. Decrease sedentary activities such as television watching and playing video and computer games to less than 2 hours per day
4. Institute several dietary changes according to the Cardiovascular Health Integrated Lifestyle diet and Dietary Approaches to Stop HTN eating plan (1) such as:
   a. Increase intake of fresh vegetables, fruits, and low-fat dairy foods
   b. Reduce carbohydrate, fat, and processed sugar intake
      i. For 4- to 18-year-olds: aim for 10% to 30% of total calories to come from protein, 45% to 65% from carbohydrate, 25% to 30% from fat
   c. Limit or avoid sugar-sweetened beverages

Table 3. Symptoms Suggesting Underlying Causes of Pediatric Hypertension

<table>
<thead>
<tr>
<th>Organ System</th>
<th>Possible Symptoms</th>
<th>Potential Diagnoses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>Chest pain, Shortness of breath, Palpitations, Claudication</td>
<td>Coarctation of the aorta, Patent ductus arteriosus, Midaortic syndrome</td>
</tr>
<tr>
<td>Endocrine</td>
<td>Weight loss or gain, Sweating, Flushing, Fever, Palpitations, Muscle cramps, Weakness, Constipation, Fatigue</td>
<td>Thyroid disease, Pheochromocytoma, Congenital adrenal hyperplasia, Cushing syndrome, Primary aldosteronism, Primary hyperparathyroidism, Hypercalcemia, Diabetes mellitus</td>
</tr>
<tr>
<td>Gynecologic</td>
<td>Last menstrual period</td>
<td>Pregnancy, Pre-eclampsia</td>
</tr>
<tr>
<td>Neurologic</td>
<td>Headache, Vision changes, Vomiting, Developmental delay, Seizures</td>
<td>Increased intracranial pressure, Guillain-Barré syndrome</td>
</tr>
<tr>
<td>Renal</td>
<td>Dysuria, Hematuria, Foamy urine (suggestive of proteinuria), Frequency, Urgency, Flank pain, Enuresis, Edema, Fatigue, Hearing loss</td>
<td>Renal parenchymal disease, Glomerulonephritis, Genitourinary anomalies, Chronic pyelonephritis, Reflux nephropathy, Polycystic kidney disease, Wilms tumor, Kidney stones</td>
</tr>
<tr>
<td>Rheumatologic</td>
<td>Rash, Joint or muscle pain, Fever, Weight change</td>
<td>Systemic lupus erythematosus, Collagen vascular disease</td>
</tr>
</tbody>
</table>

After eliciting a detailed history, the evaluation should then progress to a detailed physical examination, paying particularly close attention to findings suggestive of underlying causes (Table 4).
<table>
<thead>
<tr>
<th>Findings</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometrics</strong>&lt;br&gt;Weight, height, and appropriate percentiles&lt;br&gt;Growth failure</td>
<td>Chronic renal disease, endocrine disease, other chronic diseases&lt;br&gt;Primary hypertension, Cushing syndrome (also associated with short stature)</td>
</tr>
<tr>
<td>Anthropometrics&lt;br&gt;Obesity</td>
<td>Primary hypertension, Cushing syndrome (also associated with short stature)</td>
</tr>
<tr>
<td><strong>Vital signs</strong>&lt;br&gt;Blood pressure (4 limb) and heart rate&lt;br&gt;Lower blood pressures in lower extremities compared with upper extremities</td>
<td>Coarctation of the aorta</td>
</tr>
<tr>
<td>Vital signs&lt;br&gt;Tachycardia</td>
<td>Hyperthyroidism, pheochromocytoma, neuroblastoma, primary hypertension</td>
</tr>
<tr>
<td><strong>General examination</strong>&lt;br&gt;Volume status, overall appearance&lt;br&gt;Fluid overload or edema</td>
<td>Renal or heart failure&lt;br&gt;Cushing syndrome, steroid use&lt;br&gt;William syndrome&lt;br&gt;Turner syndrome&lt;br&gt;Pheochromocytoma</td>
</tr>
<tr>
<td>General examination&lt;br&gt;Moon facies</td>
<td>Cushing syndrome, steroid use&lt;br&gt;William syndrome&lt;br&gt;Pheochromocytoma</td>
</tr>
<tr>
<td>General examination&lt;br&gt;Elfin facies</td>
<td>Holiday syndrome&lt;br&gt;Pheochromocytoma</td>
</tr>
<tr>
<td>General examination&lt;br&gt;Webbed neck, wide-spaced nipples, short stature</td>
<td>Turner syndrome</td>
</tr>
<tr>
<td>General examination&lt;br&gt;Tall stature</td>
<td>Cushing syndrome, steroid use&lt;br&gt;Turner syndrome&lt;br&gt;Pheochromocytoma</td>
</tr>
<tr>
<td>General examination&lt;br&gt;Pallor, flushing, diaphoresis</td>
<td>Pheochromocytoma</td>
</tr>
<tr>
<td><strong>Head, eyes, ears, nose, throat including funduscopic examination</strong>&lt;br&gt;Papilledema</td>
<td>Increased intracranial pressure, hypertensive emergency, hypertensive retinopathy</td>
</tr>
<tr>
<td>Head, eyes, ears, nose, throat including funduscopic examination&lt;br&gt;Retinal hemorrhage, exudates</td>
<td>Hypertensive emergency, hypertensive retinopathy</td>
</tr>
<tr>
<td>Head, eyes, ears, nose, throat including funduscopic examination&lt;br&gt;Retinal hemorrhage, exudates</td>
<td>Hypertensive retinopathy</td>
</tr>
<tr>
<td>Head, eyes, ears, nose, throat including funduscopic examination&lt;br&gt;Retinal hemorrhage, exudates</td>
<td>Head trauma</td>
</tr>
<tr>
<td>Head, eyes, ears, nose, throat including funduscopic examination&lt;br&gt;Retinal hemorrhage, exudates</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td>Head, eyes, ears, nose, throat including funduscopic examination&lt;br&gt;Retinal hemorrhage, exudates</td>
<td>Obstructive sleep apnea</td>
</tr>
<tr>
<td><strong>Cardiovascular</strong>&lt;br&gt;Heart murmur, diminished femoral pulses</td>
<td>Coarctation of the aorta, patent ductus arteriosus</td>
</tr>
<tr>
<td>Cardiovascular&lt;br&gt;Friction rub</td>
<td>Systemic lupus erythematosus, collagen vascular disease</td>
</tr>
<tr>
<td><strong>Pulmonary</strong>&lt;br&gt;Accessory muscle use, crackles, wheeze</td>
<td>Heart failure, asthma, bronchopulmonary dysplasia</td>
</tr>
<tr>
<td><strong>Abdominal</strong>&lt;br&gt;Hepatomegaly</td>
<td>Heart failure</td>
</tr>
<tr>
<td>Abdominal&lt;br&gt;Bruit</td>
<td>Renal artery stenosis, arteriovenous fistula</td>
</tr>
<tr>
<td>Abdominal&lt;br&gt;Mass</td>
<td>Wilms tumor, neuroblastoma, pheochromocytoma</td>
</tr>
<tr>
<td>Abdominal&lt;br&gt;Palpable kidneys</td>
<td>Polycystic kidney disease, urologic disease, mass</td>
</tr>
<tr>
<td><strong>Extremities</strong>&lt;br&gt;Joint swelling</td>
<td>Systemic lupus erythematosus</td>
</tr>
<tr>
<td><strong>Neurologic</strong>&lt;br&gt;Altered mental status</td>
<td>Hypertensive encephalopathy</td>
</tr>
<tr>
<td>Neurologic&lt;br&gt;Mood</td>
<td>Anxiety, white coat hypertension</td>
</tr>
<tr>
<td>Neurologic&lt;br&gt;Weakness</td>
<td>Monogenic forms of hypertension, hyperaldosteronism</td>
</tr>
<tr>
<td><strong>Skin</strong>&lt;br&gt;Café-au-lait spots, axillary freckling, neurofibromas</td>
<td>Neurofibromatosis</td>
</tr>
<tr>
<td>Skin&lt;br&gt;Ash leaf patches, angiiofibromas, adenoma sebaceum</td>
<td>Tuberous sclerosis</td>
</tr>
<tr>
<td>Skin&lt;br&gt;Malar rash</td>
<td>Systemic lupus erythematosus</td>
</tr>
<tr>
<td>Skin&lt;br&gt;Palpable purpura</td>
<td>Henoch–Schönlein purpura, vasculitis</td>
</tr>
</tbody>
</table>

d. Encourage foods with high dietary fiber content 
\((age + 5 = \text{number of grams per day})\)

5. Salt restriction

a. Initially recommend “no added salt,” with the ultimate goal of achieving the current recommendation of 1.2 g/day total for 4- to 8-year-olds and 1.5 g/day total for children age 9 years and older(2)

6. Smoking cessation, if applicable

Children who have not experienced normalization of their BP with the above interventions after 6 months should be started on antihypertensive medications. In addition, children who present initially with secondary HTN, symptomatic HTN, left ventricular hypertrophy, or hypertensive retinopathy, or who have diabetes mellitus, should be started on antihypertensive medications at the time of diagnosis, while implementing the same lifestyle interventions. The pharmacologic agent chosen should be targeted to the underlying diagnosis, with attention being paid to existing comorbidities.

Unless contraindicated, initial therapy with either a calcium channel blocker or an angiotensin-converting enzyme inhibitor could be considered, because these medications are well-tolerated, have a minimal adverse effect profile, and can be dosed once daily. β-Blockers, angiotensin receptor blockers, and diuretics also are acceptable first-line agents for the treatment of HTN in children. The lowest dose should be started, titrating to effect until the maximum recommended dose is achieved or until the patient experiences adverse effects. At this point, if the BP is not controlled, an additional agent from another class should be added to the regimen in the same manner. Table 7 lists the major classes of antihypertensive

Table 5. Initial Laboratory and Imaging Evaluation for All Children Who Have Confirmed Hypertension

<table>
<thead>
<tr>
<th>Laboratory or Imaging Test</th>
<th>Result</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinalysis with microscopy, urine culture</td>
<td>Hematuria, proteinuria, pyuria, bacteria</td>
<td>Occult renal disease, chronic urinary tract infections</td>
</tr>
<tr>
<td>Blood urea nitrogen and creatinine levels</td>
<td>Elevated values</td>
<td>Acute kidney injury, chronic kidney disease</td>
</tr>
<tr>
<td>Electrolytes, serum calcium levels</td>
<td>Hyper- or hyponatremia, hyper- or hypokalemia, hypercalcemia</td>
<td>Endocrine or genetic forms of hypertension</td>
</tr>
<tr>
<td>Complete blood count</td>
<td>Anemia</td>
<td>Kidney disease, rheumatologic disease, chronic disease</td>
</tr>
<tr>
<td>Fasting lipid levels</td>
<td>Elevated total cholesterol, low-density lipoprotein, triglycerides, low high-density lipoprotein</td>
<td>Evaluating for co-morbidity</td>
</tr>
<tr>
<td>Fasting glucose level</td>
<td>Hyperglycemia</td>
<td>Diabetes mellitus, corticosteroid use</td>
</tr>
<tr>
<td>Plasma renin activity</td>
<td>Low or absent plasma renin activity</td>
<td>Endocrine or genetic forms of hypertension</td>
</tr>
<tr>
<td>Urine pregnancy test (all postmenarchal females)</td>
<td>Positive test</td>
<td>Pregnancy, pre-eclampsia</td>
</tr>
<tr>
<td>Renal and bladder ultrasonography</td>
<td>Mass</td>
<td>Wilms tumor, neuroblastoma, pheochromocytoma</td>
</tr>
<tr>
<td></td>
<td>Vascular malformation</td>
<td>Arteriovenous malformation</td>
</tr>
<tr>
<td></td>
<td>Bilaterally small kidneys</td>
<td>Chronic kidney disease</td>
</tr>
<tr>
<td></td>
<td>Discreant kidney sizes (≥1.5 cm)</td>
<td>Past perfusional insults, renal scar, renal artery stenosis, renal hypoplasia, renal vein thrombosis</td>
</tr>
<tr>
<td></td>
<td>Bilaterally large kidneys with or without cysts Hydronephrosis, thickened bladder</td>
<td>Cystic kidney disease, Obstructive uropathy, vesicoureteral reflux, obstructive kidney stone</td>
</tr>
<tr>
<td></td>
<td>Renal tubers Congenital anomalies</td>
<td>Tuberosclerosis, Horseshoe kidney, pelvic kidney</td>
</tr>
<tr>
<td>Echocardiography</td>
<td>Cardiac abnormalities</td>
<td>Coarctation of the aorta, congenital anomalies, heart dysfunction, pericardial effusion</td>
</tr>
<tr>
<td></td>
<td>Left ventricular hypertrophy</td>
<td>End-organ damage</td>
</tr>
</tbody>
</table>
agents with several medications from each class. (Table 7 is available in the online version of this article; visit http://pedsinreview.aappublications.org/content/33/12/541/suppl/DC1 to see Table 7.)

Table 8 lists recommendations for prescribing classes of antihypertensive agents for certain medical conditions.

The goal of antihypertensive therapy is achievement of normotension, defined as persistent systolic and diastolic BPs below the 95th percentile. In children at increased cardiovascular risk (those with chronic kidney disease, diabetes mellitus, post-heart or kidney transplantation, history of Kawasaki disease, chronic inflammatory disease, human immunodeficiency virus infection, or nephrotic syndrome) or end-organ damage (left ventricular hypertrophy or hypertensive retinopathy), the antihypertensive goal is lower. These children should be treated to achieve systolic and diastolic BPs below either the 90th percentile or 120/80 mm Hg, whichever is lower.

**Prognosis**

Children who have HTN should be followed closely to evaluate the effectiveness of prescribed antihypertensive therapy, and to reinforce medication adherence and heart-healthy behaviors. If available, BP measurements obtained by a school nurse can be useful in titrating medication dosages between clinic appointments and in monitoring therapy. Hypertensive children also should be screened intermittently for the development of end-organ damage in the form of left ventricular hypertrophy, hypertensive retinopathy, and microalbuminuria.

Children who have left ventricular hypertrophy at diagnosis should have a repeat echocardiography completed additional tests to determine secondary causes of hypertension

<table>
<thead>
<tr>
<th>Test</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine toxicology screen</td>
<td>Rule out illicit drug use</td>
</tr>
<tr>
<td>Plasma and urine steroid levels</td>
<td>Rule out steroid-mediated hypertension</td>
</tr>
<tr>
<td>Plasma metanephrines</td>
<td>Rule out pheochromocytoma</td>
</tr>
<tr>
<td>Polysomnography</td>
<td>Rule out obstructive sleep apnea</td>
</tr>
<tr>
<td>24-hour ambulatory blood pressure monitoring</td>
<td>Rule out white coat hypertension</td>
</tr>
<tr>
<td>Renal arteriogram with venous renin sampling</td>
<td>Rule out renal artery stenosis</td>
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**Medical Conditions that Warrant Specific Antihypertensive Drug Classes**

- **Diabetes**
  - Consider: ACE inhibitors, angiotensin receptor blockers (offer renoprotection and can decrease proteinuria)
  - Avoid: β-blockers (can mask signs/symptoms of hypoglycemia)
- **Migraine headaches**
  - Consider: β-blockers, calcium channel blockers (may offer symptomatic improvement for migraine headaches while controlling blood pressure)
- **Asthma**
  - Avoid: β-blockers because contraindicated for asthma (can cause bronchospasm)
- **Kidney disease and/or proteinuria**
  - Consider: ACE inhibitors, angiotensin receptor blockers (offer renoprotection and can decrease proteinuria)
- **Athlete**
  - Avoid: β-blockers, diuretics (may negatively affect athletic performance)
- **Sexually active female**
  - Avoid: ACE inhibitors, angiotensin receptor blockers (teratogenic; recommend birth control methods)
- **Obesity**
  - Consider: ACE inhibitors, angiotensin receptor blockers (may have beneficial effects on comorbidities such as diabetes and dyslipidemia)
  - Avoid: β-blockers, diuretics

β-Blockers can lead to weight gain, increased triglycerides, and decreased high-density lipoprotein cholesterol concentrations. Diuretics can worsen insulin resistance and dyslipidemia. They also can increase sympathetic nervous system neuron system and renin activity, both of which are thought to be increased in obesity-related hypertension. ACE=angiotensin-converting enzyme.
6 to 12 months after starting antihypertensive medications to ensure that their left ventricular mass has decreased with therapy. Children without evidence of left ventricular hypertrophy at diagnosis also should undergo follow-up echocardiography, because left ventricular hypertrophy can develop relatively quickly, can be seen in children who have presumably good BP control, and cannot be predicted by the severity of a child’s BP elevation. Although often clinically silent in childhood, these forms of end-organ damage are associated with significant morbidity and mortality in adulthood. The presence of any one of these entities signifies increased cardiovascular risk and the need for intensified antihypertensive treatment to reverse these findings and prevent worsening cardiovascular disease.

Some children will require long-term antihypertensive therapy into adulthood to maintain normotension. However, successful implementation of lifestyle modifications has been shown to be effective in lowering BP in both children and adults, and can allow some children to avoid or discontinue pharmacologic treatment. Children who have primary, obesity-related HTN, in particular, may be able avoid or discontinue antihypertensive medications with lifestyle modifications. Obese children have been shown to experience significant BP reductions with salt restriction, and weight loss is particularly effective at lowering BP.

Children who have secondary HTN may experience normalization of BP as their underlying disease process resolves, allowing them to discontinue medical therapy. However, when a chronic underlying condition has led to a child’s HTN, complete normalization of BP is less likely and management may require long-term antihypertensive therapy and monitoring.

**Summary**

Based on the National High Blood Pressure Education Program Working Group on Children and Adolescents consensus, which was developed from the synthesis of all available scientific evidence (2):

- Pediatric hypertension (HTN) is defined as an average of systolic or diastolic blood pressure (BP) measurements at or above the 95th percentile of BP for the child’s age, gender, and height percentile.
- All children age 3 years and older who present for care (health supervision care, urgent care, emergency care) should have their BP measured during each visit. In addition, some at-risk children younger than age 3 years also should have their BP measured at each provider visit.
- All children who have confirmed HTN should undergo an evaluation to rule out secondary causes. The age of the child and the severity of the BP elevation will dictate how extensive this evaluation should be.
- Once a child is diagnosed as having HTN and has undergone an evaluation, antihypertensive therapy should be initiated, which includes lifestyle modification for all children and pharmacologic therapy for some children.

**References**

PIR Quiz

This quiz is available online at http://www.pedsinreview.aappublications.org. NOTE: Since January 2012, learners can take Pediatrics in Review quizzes and claim credit online only. No paper answer form will be printed in the journal.

Pediatrics in Review QuizNew Minimum Performance Level Requirements

Per the 2010 revision of the American Medical Association (AMA) Physician’s Recognition Award (PRA) and credit system, a minimum performance level must be established on enduring material and journal-based CME activities that are certified for AMA PRA Category 1 Credit™. In order to successfully complete 2012 Pediatrics in Review articles for AMA PRA Category 1 Credit™, learners must demonstrate a minimum performance level of 60% or higher on this assessment, which measures achievement of the educational purpose and/or objectives of this activity.

Starting with the 2012 issues of Pediatrics in Review, AMA PRA Category 1 Credit™ may be claimed only if 60% or more of the questions are answered correctly. If you score less than 60% on the assessment, you will be given additional opportunities to answer questions until an overall 60% or greater score is achieved.

1. A 4-year-old girl has had blood pressure measurements taken by manual blood pressure cuff with the use of the proper technique of 142/85, 138/81, and 135/80 mm Hg during three different measurements at the beginning, middle, and end of an office visit, with rest between each measurement. She is healthy with no significant past medical history, and she takes no medications. She has no family history of hypertension. The findings of her physical examination are within normal limits with height and weight at the 75th percentile. You are most likely to take which of the following steps next:
   A. Compare blood pressure measurements in her upper and lower extremities.
   B. Reassure her mother that because her blood pressure is lower at the end of the visit, no further evaluation is needed.
   C. Recommend a follow-up visit in 1 week to recheck her blood pressure.
   D. Refer her for genetic evaluation for underlying genetic syndrome.
   E. Refer her to the emergency department for urgent blood pressure management.

2. A 10-year-old girl has had elevated blood pressure noted on several measurements during several clinic visits in the past year. She is healthy with no significant past medical history, and she takes no medications. She has no family history of hypertension. The findings of her physical examination are unremarkable; her height is at the 3rd percentile and her weight at the 25th percentile. On examination today, her blood pressure in her right arm is 140/85 mm Hg, and her blood pressure in her right leg is 108/68 mm Hg. She is most likely to have the following underlying syndrome or condition:
   A. Cushing syndrome.
   B. Neurofibromatosis.
   C. Tuberous sclerosis.
   D. Turner syndrome.
   E. Williams syndrome.

3. A 9-month-old boy has had elevated blood pressure noted during each of his health care maintenance evaluations. He was born at 30 weeks’ gestation and was discharged from the NICU at age 2 months. He breastfeeds and eats pureed fruits and vegetables. He has no family history of hypertension. His growth parameters are at the 25th percentile, corrected for prematurity. On examination today, his blood pressure in his right arm is 95/75 mm Hg, and his blood pressure in his right leg is 100/76 mm Hg. Further history is most likely to reveal the following:
   A. Coarctation of the aorta.
   B. Elevated maternal caffeine intake.
   C. History of neonatal seizures.
   D. History of umbilical catheter placement.
   E. Hyperthyroidism.
4. You see a 15-year-old obese boy who has persistent hypertension after 6 months of lifestyle modification. His 40-year-old father takes medication for hypertension. His past medical history is significant for asthma. The findings of his physical examination are normal except for his obesity. You are most likely to recommend initiating treatment with the following:

A. Furosemide.
B. Hydrochlorothiazide.
C. Labetalol.
D. Lisinopril.
E. Propranolol.

5. A 15-year-old girl was born at 34 weeks’ gestation. She was cared for in the NICU for 3 weeks for feeding issues, but had no respiratory or cardiovascular concerns. She has been healthy since infancy. Her 40-year-old father takes medication for hypertension. Her blood pressure was 132/85 mm Hg 2 weeks ago, and, during this follow-up examination, her blood pressure is 135/80, 131/82, and 132/83 mm Hg on three measurements. Her height is at the 50th percentile, and her weight is at the 90th percentile. On physical examination, she has two 1.5-cm café-au-lait spots and a grade II/VI heart murmur at the left upper sternal border. The findings of the remainder of her examination are normal. The most likely cause of the findings on examination is

A. Coarctation of the aorta.
B. Neurofibromatosis.
C. Obesity.
D. Primary hypertension.
E. Renovascular disease related to prematurity.

HealthyChildren.org Parent Resources From the AAP
The reader is likely to find material to share with parents that is relevant to this article by visiting this link: