HIPERTENSIÓN ARTERIAL EN NIÑOS Y ADOLESCENTES

7° Congreso Argentino de Pediatría General Ambulatoria
2018

Sofía G. Berman
Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents

Flynn JT, Kaelber DC, Baker-Smith CM, et al.
Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents.
_Pediatrics._ 2017;140(3):e20171904

..... to address the following key questions:
What is the **optimal approach to diagnose HTN** in children & adolescents?

How do we best identify the **underlying etiologies of secondary HTN** in children?

What is the **optimal goal** systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) for children and adolescents?

In children 0 to 18 years of age, **how does treatment** with lifestyle versus antihypertensive agents **influence indirect measures of cardiovascular disease risk**?
Epidemiology and Clinical Significance

Prevalence of HTN in Children

- The actual **prevalence** of clinical HTN in children and adolescents is ~3.5%.

- The prevalence of **persistently elevated BP** (formerly termed “prehypertension” including BP values from the 90th to 94th percentiles or between 120/80 and 130/80 mm Hg in adolescents) is also ~2.2% to 3.5%, with **higher rates** among children and adolescents who have **overweight and obesity**.

- Data on BP **tracking from childhood to adulthood** demonstrate that higher BP in childhood correlates with higher BP in adulthood & the onset of HTN in young adulthood.

- The data confirm the **association of elevated BP in adolescence with HTN in early adulthood** & that normal BP in childhood is associated with a lack of HTN in midadulthood.
Epidemiology and Clinical Significance

Prevalence of HTN Among Children With Various Chronic Conditions

Children With Obesity

- **HTN prevalence** ranges from 3.8% to 24.8% in youth with **overweight and obesity**.
- **Rates of HTN increase** in a graded fashion with ↑**adiposity & waist circumference**.
- **Obesity** is also associated with a lack of circadian variability of BP, with up to 50% of children who have obesity not experiencing the expected nocturnal BP dip.
- Studies shown that **childhood obesity is related to the development of future HTN**. This risk appears to increase with obesity severity.
- The data underscore the **importance of monitoring BP** in all children with **overweight and/or obesity at every clinical encounter**.
- **Obesity in children with HTN may be accompanied by additional cardiometabolic risk factors** (eg, dyslipidemia and disordered glucose metabolism) that may have their own effects on BP or may represent comorbid conditions arising from the same adverse lifestyle behaviors.
Epidemiology and Clinical Significance

Prevalence of HTN Among Children With Various Chronic Conditions

**Children With Sleep-Disordered Breathing**

- SDB occurs on a **spectrum** that includes:
  - primary snoring,
  - sleep fragmentation
  - obstructive sleep apnea syndrome (OSAS)

- Numerous studies have identified an **association between SDB and HTN** in the pediatric population. Small studies of youth with sleep disorders have found the prevalence of high BP to range between **3.6% and 14%**.

- Even **inadequate duration of sleep and poor-quality sleep** have been associated with elevated BP. Studies suggest that children who sleep ≤7 hours / night are at increased risk for HTN.

- The **more severe** the OSAS, the **more likely** a child is to have HTN.
Epidemiology and Clinical Significance

Prevalence of HTN Among Children With Various Chronic Conditions

**Children With Chronic Kidney Disease**

- There are well-established **pathophysiologic links** between childhood HTN and CKD.
- **Untreated HTN can lead to CKD in adults**, although evidence for the latter in pediatric patients is lacking.
- **Among children and adolescents with CKD**, ~50% are known to be hypertensive.
- In children and adolescents with **end-stage renal disease** (either those on dialysis or after transplant), **48% to 79% are hypertensive**, 20% to 70% having uncontrolled HTN.
- Almost 20% of pediatric HTN may be attributable to CKD.
Abnormal birth history—including preterm birth and low birth weight—has been identified as a risk factor for HTN and other CVD in adults.

Only low birth weight has been associated with elevated BP in the pediatric age range.

One retrospective cohort study showed a prevalence of HTN of 7.3% among 3 year olds who were born preterm.

Researchers in another retrospective case series noted a high prevalence of HTN in older children with a history of preterm birth.

It appears that preterm birth may result in abnormal circadian BP patterns in childhood.

These data are intriguing but limited. Further study is needed to determine how often preterm birth results in childhood HTN.
Definition of HTN
(1–18 Years of Age)

BP levels should be interpreted on the basis of sex, age, and height.

Updated Definitions of BP Categories and Stages

<table>
<thead>
<tr>
<th>For Children Aged 1–13 y</th>
<th>For Children Aged ≥13 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal BP: &lt;90th percentile</td>
<td>Normal BP: &lt;120/&lt;80 mm Hg</td>
</tr>
<tr>
<td>Elevated BP: ≥90th percentile to &lt;95th percentile or 120/80</td>
<td>Elevated BP: 120/&lt;80 to 129/&lt;80 mm Hg</td>
</tr>
<tr>
<td>mm Hg to &lt;95th percentile (whichever is lower)</td>
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</tr>
<tr>
<td>Stage 1 HTN: ≥95th percentile to &lt;95th percentile + 12 mmHg,</td>
<td>Stage 1 HTN: 130/80 to 139/89 mm Hg</td>
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<tr>
<td>or 130/80 to 139/89 mm Hg (whichever is lower)</td>
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</tr>
<tr>
<td>Stage 2 HTN: ≥95th percentile + 12 mm Hg, or ≥140/90 mm Hg</td>
<td>Stage 2 HTN: ≥140/90 mm Hg</td>
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<tr>
<td>(whichever is lower)</td>
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</tbody>
</table>
## Screening BP Values Requiring Further Evaluation

<table>
<thead>
<tr>
<th>Age,</th>
<th>BP, mm Hg</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systolic</td>
<td>DBP</td>
<td>Systolic</td>
</tr>
<tr>
<td>1</td>
<td>98</td>
<td>52</td>
<td>98</td>
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<tr>
<td>2</td>
<td>100</td>
<td>55</td>
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<td>12</td>
<td>113</td>
<td>75</td>
<td>114</td>
</tr>
<tr>
<td>≥13</td>
<td>120</td>
<td>80</td>
<td>120</td>
</tr>
</tbody>
</table>
Definition of HTN in the Neonate and Infant (0–1 Year of Age)

Measurement of BP

BP Measurement Technique

- **BP in childhood may vary considerably** between visits & during the same visit.
- There are many potential etiologies for **isolated elevated BP** in children and adolescents, including such factors as **anxiety and recent caffeine intake**.
- **BP generally decreases with repeated measurements during a single visit**, although the variability may not be large enough to affect BP classification.
- Important to obtain **multiple measurements over time before diagnosing HTN**.

BP measurement are illustrated in an AAP video available at https://www.youtube.com/watch?v=JLzkNBpqwi0&feature=youtu.be
Best BP Measurement Practices

- The child should be **seated** in a quiet room for 3–5 min before measurement, with the back supported and **feet uncrossed** on the floor.

- BP should be measured in the **right arm** for consistency, for comparison with **standard tables**, and to avoid a falsely low reading from the **left arm** in the case of **coarctation of the aorta**.

- The **arm** should be **at heart level, 90 supported**, and uncovered above the cuff.

- The patient and observer should **not speak** while the measurement is being taken.

- The **correct cuff size** should be used. The bladder **length** should be 80%–100% of the arm, and the **width** should be at least 40%.

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For an auscultatory BP, the bell of the stethoscope should be placed over the brachial artery in the antecubital fossa, and the lower end of the cuff should be 2–3 cm above the antecubital fossa.

The cuff should be inflated to 20–30 mm Hg above the point at which the radial pulse disappears. Overinflation should be avoided.

The cuff should be deflated at a rate of 2–3 mm Hg per second. The first (phase I Korotkoff) and last (phase V Korotkoff) audible sounds should be taken as SBP and DBP. If the Korotkoff sounds are heard to 0 mm Hg, the point at which the sound is muffled (phase IV Korotkoff) should be taken as the DBP, or the measurement repeated with less pressure applied over the brachial artery. The measurement should be read to the nearest 2 mm Hg.

To measure BP in the legs, the patient should be in the prone position, if possible. An appropriately sized cuff should be placed mid thigh and the stethoscope placed over the popliteal artery. The SBP in the legs is usually 10%–20% higher than the brachial artery pressure.

It is **unclear what age is optimal to begin routine BP measurement** in children.

**Recommendation:** beginning measure BP in ambulatory setting **at 3 years of age.**

For otherwise healthy children, **BP need only be measured annually** rather than during every health care encounter.

Some children should have BP measured **at every health encounter**, specifically those with **obesity** (BMI ≥95 percentile), **renal disease, diabetes, aortic arch obstruction or coarctation**, or those who are taking **medications** that increase BP.

Children **younger than 3 years** should have BP measurements taken at well-child care visits **if they are at increased risk for developing HTN.**
<table>
<thead>
<tr>
<th>Conditions Under Which Children Younger Than 3 Years Should Have BP Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of prematurity &lt;32 week’s gestation or small for gestational age, very low birth weight, other neonatal complications requiring intensive care, umbilical artery line</td>
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<tr>
<td>Congenital heart disease (repaired or un repaired)</td>
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<tr>
<td>Recurrent urinary tract infections, hematuria, or proteinuria</td>
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<tr>
<td>Known renal disease or urologic malformations</td>
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<tr>
<td>Family history of congenital renal disease</td>
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<tr>
<td>Solid-organ transplant</td>
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<tr>
<td>Malignancy or bone marrow transplant</td>
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<tr>
<td>Treatment with drugs known to raise BP</td>
</tr>
<tr>
<td>Other systemic illnesses associated with HTN (neurofibromatosis, tuberous sclerosis, sickle cell disease, etc.)</td>
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<tr>
<td>Evidence of elevated intracranial pressure</td>
</tr>
</tbody>
</table>
Patient Management on the Basis of Office BP

**Normal BP**

If BP is normal or normalizes after repeat readings (ie, BP <90\textsuperscript{th} percentile)

- no additional action is needed
- practitioners should measure the BP at the next routine well-child care visit
**Patient Management on the Basis of Office BP**

### Elevated BP

- If the BP reading is **at the elevated BP level** lifestyle interventions should be recommended (ie, healthy diet, sleep, and physical activity); the **measurement should be repeated in 6 months** by auscultation. **Nutrition &/or weight management referral should be considered**

- If BP remains at the elevated BP level after 6 months, upper and lower extremity BP should be rechecked (**right arm, left arm, and 1 leg**), **lifestyle counseling should be repeated**, and **BP should be rechecked in 6 months**.

- If BP continues at the elevated BP level after 12 months (after 3 auscultatory measurements), **ABPM should be ordered and diagnostic evaluation should be conducted**. **Consider subspecialty referral** (ie, cardiology or nephrology).

- If BP normalizes at any point, return to annual BP screening at well-child care visits.
Patient Management on the Basis of Office BP

**Stage 1 HTN**

- If the BP reading is at the **stage 1 HTN level** and the patient is **asymptomatic**, provide **lifestyle counseling** and recheck the BP in **1 to 2 weeks** by auscultation.

- If the BP reading is **still at the stage 1 level**, upper and lower extremity BP should be checked (**right arm, left arm, and 1 leg**), and BP should be **rechecked in 3 months** by auscultation. **Nutrition and/or weight management referral should be considered**.

- If BP continues to be at the **stage 1 HTN level after 3 visits**,  
  - **ABPM** should be ordered  
  - **diagnostic evaluation** should be conducted  
  - **treatment** should be initiated  
  - **subspecialty referral** should be considered
Patient Management on the Basis of Office BP

**Stage 2 HTN**

- upper and lower extremity BP should be checked (right arm, left arm, and 1 leg),
- lifestyle recommendations given,
- the BP measurement should be repeated within 1 week.
- alternatively, the patient could be referred to subspecialty care within 1 week.

- If the BP reading is still at the stage 2 HTN level when repeated:
  - diagnostic evaluation, including ABPM, should be conducted
  - treatment should be initiated,
  - or the patient should be referred to subspecialty care within 1 week.

- If the BP reading is at the stage 2 HTN level and the patient is symptomatic, or the BP is >30 mm Hg above the 95th percentile (or >180/120 mm Hg in an adolescent),
  - refer to an immediate source of care, such as an emergency department

- Trained health care professionals in the office setting should make a diagnosis of HTN if a child or adolescent has BP readings ≥95th percentile on 3 different visits.
An ambulatory BP monitor **consists of a BP cuff attached to a box** slightly larger than a cell phone, **which records BP periodically** (usually every 20–30 minutes) throughout the **day and night**; these data are later **downloaded to a computer for analysis**.

ABPM has been **recommended** by the US Preventive Services Task Force for the confirmation of **HTN in adults** before starting treatment. Although a growing number of pediatric providers have access to ABPM, **there are still gaps** in access and knowledge regarding the **optimal application of ABPM to the evaluation of children’s BP**.

However, **sufficient data exist** to demonstrate that **ABPM is more accurate for the diagnosis of HTN than clinic-measured BP**, is **more predictive of future BP**, & can assist in the **detection of 2*HTN**. Furthermore, **increased LVMI and LVH correlate strongly with ABPM parameters than casual BP**, & **ABPM is reproducible** than casual or home BP measurement. **For these reasons, the routine application of ABPM is recommended**.

For **technical reasons**, ABPM may need to be limited to **children ≥5 years of age** who can tolerate the procedure and those for whom reference data are available.
The routine performance of ABPM should be strongly considered in children & adolescents with high-risk conditions to assess HTN severity and determine if abnormal circadian BP patterns are present, which may indicate increased risk for target organ damage.

*Masked Hypertension* occurs when patients have normal office BP but elevated BP on ABPM, and it has been found in 5.8% of unselected children studied by ABPM. There is growing evidence that compared with those with normal 24-hour BP, these patients have significant risk for end organ hypertensive damage. Patients who are at risk of MH include patients with obesity and secondary forms of HTN, such as CKD or repaired aortic coarctation. MH is particularly prevalent in patients with CKD and is associated with target organ damage.

- Children with CKD should be periodically evaluated using ABPM for MH as part of routine CKD management.

*White Coat Hypertension* WCH is defined as BP ≥95th percentile in the office or clinical setting but <95th percentile outside of the office or clinical setting. WCH is diagnosed by ABPM when the mean SBP and DBP are <95th percentile and SBP and DBP load are <25%; load is defined as the percentage of valid ambulatory BP measurements above a set threshold value (eg, 95th percentile) for age, sex, and height. It is estimated that up to half of children who are evaluated for elevated office BP have WCH.

- Children and adolescents with WCH should have screening BP measured at regular well-child care visits with consideration of a repeat ABPM in 1 to 2 years.
# High-Risk Conditions for Which ABPM May Be Useful

<table>
<thead>
<tr>
<th>Condition</th>
<th>Rationale</th>
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<tbody>
<tr>
<td>Secondary HTN</td>
<td>Severe ambulatory HTN or nocturnal HTN indicates higher likelihood of secondary HTN(^1)(^2),(^1)(^7) Evaluate for MH or nocturnal HTN(^1)(^8)–(^1)(^7) better control delays progression of renal disease(^1)(^7) Evaluate for abnormal ABPM patterns,(^1)(^7)(^4),(^1)(^7)(^5) better BP control delays the development of MA(^1)(^7)(^6)–(^1)(^7)(^9) Evaluate for MH or nocturnal HTN, better control BP(^1)(^7)(^8)–(^1)(^7)(^9) Evaluate for WCH and MH(^1)(^8)–(^1)(^9) Evaluate for nondipping and accentuated morning BP surge(^1)(^3),(^1)(^4),(^1)(^6),(^1)(^3)(^4) Evaluate for sustained HTN and MH(^1)(^8),(^1)(^1)(^2),(^1)(^1)(^3) HTN associated with increased arterial stiffness may only be manifest with activity during ABPM(^1)(^8),(^1)(^9) Confirm 24-h BP control(^1)(^5) Evaluate for nondipping(^1)(^9) To reduce sample size(^1)(^7)</td>
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<tr>
<td>CKD or structural renal abnormalities</td>
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<td>T1DM and T2DM</td>
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<td>Solid-organ transplant</td>
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<td>Obesity</td>
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<tr>
<td>OSAS</td>
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<tr>
<td>Aortic coarctation (repaired)</td>
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<tr>
<td>Genetic syndromes associated with HTN (neurofibromatosis, Turner syndrome, Williams syndrome, coarctation of the aorta)</td>
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<tr>
<td>Treated hypertensive patients</td>
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<tr>
<td>Patient born prematurely</td>
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<tr>
<td>Research, clinical trials</td>
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</table>
Home measurement (or selfmonitoring) of BP has advantages over both office and ambulatory monitoring:
- convenience & ability to repeat measurements over time.

Furthermore, automated devices with memory capacity are straightforward to use.

Home BP monitoring should not be used to diagnose HTN, MH, or WCH but may be a useful adjunct to office and ambulatory BP measurement after HTN has been diagnosed.
Primary and Secondary Causes of HTN

Primary HTN

- Primary HTN is now the **predominant diagnosis for hypertensive children and adolescents** seen in referral centers in the United States, although single-center studies from outside the United States still find primary HTN to be uncommon.

- **General characteristics of children with primary HTN** include:
  - older age (≥6 years)
  - positive family history (in a parent and/or grandparent) of HTN,
  - overweight &/or obesity

- **Severity** of BP elevation **has not differed** significantly between children with primary and secondary HTN in some studies, but **DBP elevation appears to be more predictive of secondary HTN**, whereas **systolic HTN appears to be more predictive of primary HTN**.

- Children and adolescents ≥6 years of age do not require an extensive evaluation for secondary causes of HTN if:
  - they have a positive family history of HTN
  - are overweight or obese
  - don't have history or physical examination findings suggestive of a 2* cause of HTN
Secondary Causes: Renal and/or Renovascular

- **Renal disease and renovascular disease:**
  - among the most common secondary causes of HTN in children.

- Renal parenchymal disease and renal structural abnormalities accounted for 34% to 79% of patients with secondary HTN in 3 retrospective, single-center case series, and renovascular disease was present in 12% to 13%.

- It is appropriate to have a high index of suspicion for renal and renovascular disease in hypertensive pediatric patients, particularly in those <6 years of age.
Coarctation of the aorta is a congenital abnormality of the aortic arch characterized by discrete narrowing of the aortic arch, generally at the level of the aortic isthmus, usually associated with HTN & right arm BP is ≥20 mm Hg greater than the lower extremity BP.

Long-segment narrowing of the abdominal aorta can also cause HTN and should be considered in children with refractory HTN and a gradient between the upper and lower extremities. Of note, children with abdominal aortic obstruction may have Neurofibromatosis, Williams syndrome, Alagille syndrome, or Takayasu arteritis.

Patients with coarctation can remain hypertensive or develop HTN even after early and successful repair. HTN can be a manifestation of recoarctation.

The prevalence of HTN increases over time after successful coarctation repair.

Children and adolescents who have undergone coarctation repair should undergo ABPM for the detection of HTN, at most, 12 years after coarctation repair. Earlier screening may be considered on the basis of risk factors and clinician discretion.
Systemic arterial hypertension following coarctation repair is common & often observed even in patients with a successful COA repair with minimal or no residual gradient in the aortic arch.

**Prevalence**
- **during childhood** following early repair of COA is ± 30%
- up to 68% in long-term follow-up studies **in young adults**
Hypertension in Coarctation of the Aorta: Challenges in Diagnosis in Children
Pediatr Cardiol (2018) 39:1–10

Aetiology → multifactorial
- Aortic arch morphology
- Surgical techniques
- Innate abnormalities of the aortic wall
- Residual aortic pressure gradients following repair
- Altered regulation of renin–angiotens & baroreceptor system
- Age at presentation and the timing of surgery
Hypertension in Coarctation of the Aorta: Challenges in Diagnosis in Children

Pediatr Cardiol (2018) 39:1–10

Gothic aortic arch
Crenel aortic arch
Romanesque aortic arch
Secondary Causes: **Endocrine HTN**

- HTN resulting from *hormonal excess* accounts for a *relatively small proportion* of children with 2*HTN* (prevalence 0.05% to 6%). An accurate *diagnosis of endocrine HTN provides a unique treatment opportunity* to surgical cure or pharmacologic therapy.

Secondary Causes: **Environmental Exposures**

- Several environmental exposures (e.g.: *lead, cadmium, mercury, and phthalates*) are associated with ↑childhood BP, although most studies are limited to small case series.

Secondary Causes: **Neurofibromatosis**

- **Neurofibromatosis type 1** (Von Recklinghausen disease) is a rare autosomal dominant disorder with *potential secondary causes of HTN*, most commonly *renal artery stenosis*, and also *coarctation of the aorta, middle aortic syndrome*, and *pheochromocytoma*. Additionally, an ↑incidence of *idiopathic HTN* was documented in NF-1, as high as 6.1%.
<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over-the-counter</td>
<td>Decongestants, Caffeine</td>
</tr>
<tr>
<td>drugs</td>
<td>Nonsteroidal anti-inflammatory drugs</td>
</tr>
<tr>
<td></td>
<td>Alternative therapies, herbal and nutritional</td>
</tr>
<tr>
<td></td>
<td>supplements</td>
</tr>
<tr>
<td>Prescription</td>
<td>Stimulants for attention-deficit/hyperactivity</td>
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<tr>
<td>drugs</td>
<td>disorder</td>
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<tr>
<td></td>
<td>Hormonal contraception</td>
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<tr>
<td></td>
<td>Steroids</td>
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<tr>
<td></td>
<td>Tricyclic antidepressants</td>
</tr>
<tr>
<td>Illicit drugs</td>
<td>Amphetamines, Cocaine</td>
</tr>
</tbody>
</table>
Secondary Causes: Monogenic HTN

- Monogenic forms of HTN are uncommon, although the exact incidence is unknown.
- In a study of select hypertensive children without a known etiology, genetic testing for familial hyperaldosteronism type I (FH-I), or glucocorticoid remediable aldosteronism, confirmed responsible genetic mutations in 3% of the population.
- Other monogenic forms of HTN: Liddle syndrome, pseudohypo-aldosteronism type II (Gordon syndrome), apparent mineralocorticoid excess, familial glucocorticoid resistance, mineralocorticoid receptor activating mutation, and congenital adrenal hyperplasia.
- All manifest as HTN with suppressed plasma renin activity (PRA) and increased sodium absorption in the distal tubule. Other features may include serum potassium abnormalities, metabolic acid-base disturbances, and abnormal plasma aldosterone concentrations, although the clinical presentations can be highly variable.
- Suspect Monogenic forms of HTN in children with a suppressed Plasma Renin Activity or elevated Aldosterone-to-Renin Ratio, especially with a family history of early-onset HTN.
As with any medical condition, appropriate diagnostic evaluation is critical to determine possible causes &/or comorbidities associated with HTN.

- patient & family history, physical examination, laboratory evaluation, & imaging.

The first step is to obtain a history:

- perinatal, past medical, nutritional - activity & psychosocial history.

Perinatal factors such as maternal HTN and low birth weight have been shown to influence later BP, even in childhood. Additionally, a high incidence of preterm birth among hypertensive children has recently been reported. Thus, it is appropriate to obtain a history of pertinent prenatal information:

- maternal pregnancy complications; gestational age; birth weight;
- complications occurring in the neonatal nursery
- document pertinent procedures, such as umbilical catheter placement.
High sodium intake is linked to childhood HTN & increased LVMI and is the focus of several population health campaigns.

- In NHANES 2003–2008, among children 8 to 18 years of age (n = 6235), higher sodium intake was associated with a twofold increase in the combined outcome of elevated BP or HTN & threefold in participants with obesity. Limited data suggest the same effect is in younger children.

- ↑ intake of total fat /saturated fat & adiposity /central obesity: also predictors of SBP.

- Nutrition history is an important part of the assessment because it may identify dietary contributors to HTN & detect areas in which lifestyle modification may be appropriate.

- Important components to discuss are:
  - salt intake (kitchen /at the table/Na hidden in processed & fast food)
  - consumption of high-fat foods, & sugary beverages
  - infrequent consumption of fruits, vegetables, and low-fat dairy products
Diagnostic Evaluation

Patient Evaluation: Psychosocial History

- **Adverse experiences** both prenatally and during childhood (including maltreatment, early onset depression, and anxiety) are associated with adult-onset HTN.

- The psychosocial history should include feelings of depression / anxiety, bullying, & body perceptions. The latter is particularly important for patients with overweight or obesity because **∼70% of these children report having bullying and body perception concerns.**

- Starting at **11 years of age**, the psychosocial history should include questions about smoking, alcohol, and other drug use.

Patient Evaluation: Family History

- To risk-stratify pediatric patients with an increased risk for HTN
Diagnostic Evaluation

Patient Evaluation: *Physical Examination*

- May provide clues to 2* causes of HTN & assess possible hypertensive end organ damage.

- The child’s **height, weight, BMI, and percentiles for age** should be determined at the start of the physical examination. **Poor growth** may indicate an underlying chronic illness.

- At the 2\textsuperscript{nd} visit with confirmed elevated BP or stage 1 HTN, or the 1\textsuperscript{st} visit with stage 2 HTN,
  - BP should be measured in both arms and in a leg.
  - Normally, BP is 10 to 20 mm Hg higher in the legs than the arms.

- If the leg BP is < than the arm BP, or if femoral pulses are weak or absent:
  - coarctation of the aorta may be present.

- The physical examination in HTN children is frequently normal except for the BP ↑.
Examples of Physical Examination Findings and History Suggestive of Secondary HTN or Related to End Organ Damage

<table>
<thead>
<tr>
<th>Body System</th>
<th>Finding, History</th>
<th>Possible Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital signs</td>
<td>Tachycardia</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PCC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neuroblastoma</td>
</tr>
<tr>
<td></td>
<td>Decreased lower extremity pulses; drop in BP from upper to lower extremities</td>
<td>Coarctation of the aorta</td>
</tr>
<tr>
<td>Eyes</td>
<td>Proptosis</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>Retinal changes(^a)</td>
<td>Severe HTN, more likely to be associated with secondary HTN</td>
</tr>
<tr>
<td>Ear, nose, throat</td>
<td>Adenotonsillar hypertrophy</td>
<td>SDB</td>
</tr>
<tr>
<td></td>
<td>History of snoring</td>
<td>Sleep apnea</td>
</tr>
<tr>
<td>Height, weight</td>
<td>Growth retardation</td>
<td>Chronic renal failure</td>
</tr>
<tr>
<td></td>
<td>Obesity (high BMI)</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td></td>
<td>Truncal obesity</td>
<td>Insulin resistance syndrome</td>
</tr>
<tr>
<td>Head, neck</td>
<td>Elfin facies</td>
<td>Williams syndrome</td>
</tr>
<tr>
<td></td>
<td>Moon facies</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td></td>
<td>Thyromegaly, goiter</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>Webbed neck</td>
<td>Turner syndrome</td>
</tr>
<tr>
<td>Skin</td>
<td>Pallor, flushing, diaphoresis</td>
<td>PCC</td>
</tr>
<tr>
<td></td>
<td>Acne, hirsutism, striae</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anabolic steroid abuse</td>
</tr>
<tr>
<td></td>
<td>Café-au-lait spots</td>
<td>Neurofibromatosis</td>
</tr>
<tr>
<td></td>
<td>Adenoma sebaceum</td>
<td>Tuberous sclerosis</td>
</tr>
<tr>
<td></td>
<td>Malar rash</td>
<td>Systemic lupus</td>
</tr>
<tr>
<td></td>
<td>Acanthosis nigricans</td>
<td>T2DM</td>
</tr>
<tr>
<td>Hematologic</td>
<td>Pallor</td>
<td>Renal disease</td>
</tr>
</tbody>
</table>
### Examples of Physical Examination Findings and History Suggestive of Secondary HTN or Related to End Organ Damage

<table>
<thead>
<tr>
<th>Chest, cardiac</th>
<th>Chest pain</th>
<th>Heart disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Palpitations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exertional dyspnea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Widely spaced nipples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heart murmur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Friction rub</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abdomen</th>
<th>Apical heave(^a)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abdominal mass</td>
<td></td>
</tr>
</tbody>
</table>

|                    | Epigastric, flank bruit             |                               |
|                    | Palpable kidneys                   |                               |

- Turner syndrome
- Coarctation of the aorta
- Systemic lupus (pericarditis)
- Collagen vascular disease
- LVH
- Wilms tumor
- Neuroblastoma
- PCC
- RAS
- Polycystic kidney disease
- Hydronephrosis
- Multicystic dysplastic kidney
**Examples of Physical Examination Findings and History Suggestive of Secondary HTN or Related to End Organ Damage**

<table>
<thead>
<tr>
<th>Genitourinary</th>
<th>Ambiguous or virilized genitalia</th>
<th>Congenital adrenal hyperplasia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urinary tract infection</td>
<td>Renal disease</td>
</tr>
<tr>
<td></td>
<td>Vesicoureteral reflux</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hematuria, edema, fatigue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abdominal trauma</td>
<td></td>
</tr>
<tr>
<td>Extremities</td>
<td>Joint swelling</td>
<td>Systemic lupus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collagen vascular disease</td>
</tr>
<tr>
<td></td>
<td>Muscle weakness</td>
<td>Hyperaldosteronism</td>
</tr>
<tr>
<td>Neurologic, metabolic</td>
<td>Hypokalemia, headache, dizziness,</td>
<td>Liddle syndrome</td>
</tr>
<tr>
<td></td>
<td>polyuria, nocturia</td>
<td>Reninoma</td>
</tr>
<tr>
<td></td>
<td>Muscle weakness, hypokalemia</td>
<td>Monogenic HTN (Liddle syndrome,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GRA, AME)</td>
</tr>
</tbody>
</table>
The purpose of the laboratory evaluation is **to identify underlying secondary causes of HTN** (eg, renal or endocrine disease) that would require specific treatment guided by a subspecialist.

In general, such testing includes a basic **set of screening tests and additional, specific tests**; the latter are selected on the basis of clues obtained from the history and physical examination and/or the results of the initial screening tests.
### Patient Management on the Basis of Office BP

#### Screening Tests and Relevant Populations

<table>
<thead>
<tr>
<th>Patient Population</th>
<th>Screening Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>Urinalysis&lt;br&gt;Chemistry panel, including electrolytes, blood urea nitrogen, and creatinine&lt;br&gt;Lipid profile (fasting or nonfasting to include high-density lipoproteina and total cholesterol)&lt;br&gt;Renal ultrasonography in those &lt;6 y of age or those with abnormal urinalysis or renal function</td>
</tr>
<tr>
<td>In the obese (BMI &gt;95th percentile) child or adolescent, in addition to the above</td>
<td>Hemoglobin A1c (accepted screen for diabetes)&lt;br&gt;Aspartate transaminase and alanine transaminase (screen for fatty liver)&lt;br&gt;Fasting lipid panel (screen for dyslipidemia)&lt;br&gt;Fasting serum glucose for those at high risk for diabetes mellitus&lt;br&gt;Thyroid-stimulating hormone&lt;br&gt;Drug screen&lt;br&gt;Sleep study (if loud snoring, daytime sleepiness, or reported history of apnea)&lt;br&gt;Complete blood count, especially in those with growth delay or abnormal renal function</td>
</tr>
</tbody>
</table>

High specificity but poor sensitivity for identifying LVH.

ECG positive predictive value to identify LVH is extremely low.

Clinicians should not perform ECG in hypertensive children and adolescents being evaluated for LVH.
To measure left ventricular target organ injury related to HTN

Basis for this assessment:
- the relationship of LV mass to BP
- independent strong relation LVH / adverse adults CVD outcomes

Antihypertensive treatment reduces LVH.

Observational data suggest that regression of LVH independently predicts outcomes in adults.

- LVEF may be ↓↓ in severe or acute onset HTN with associated congestive heart failure.
- Rarely, LVEF may be mildly depressed in chronic HTN
Imaging Evaluation

Echocardiography: *Key Action*

- Performed ECHO to assess for cardiac target organ damage (LV mass, geometry, & function) **at the time of consideration of pharmacologic treatment** of HTN.

- **LVH should be defined** as:
  - LV mass >51 g/m (boys and girls) for children and adolescents >than 8 years,
  - LV mass >115 g/BSA in boys
  - LV mass >95 g/BSA in girls.

- **Repeat** ECHO to monitor improvement or progression of target organ damage
  - at 6- to 12-month intervals.
Emerging data demonstrate association of **BP higher levels in youth with adverse changes in measures of vascular structure & function**, including **ultrasonography** of the **cIMT, PWV**, a robust measure of central arterial stiffness related to hard CV events in adults (eg, stroke, myocardial infarction, etc), & **FMD**.

**Insufficient normative data** are available to define clinically actionable cut-points between normal and abnormal for these vascular parameters in **children**.

**The routine measurement of vascular structure and function to stratify risk in hypertensive youth cannot be recommended at this time.**
Diagnostic Evaluation

Imaging for Renovascular Disease

- There are no evidence-based criteria for the identification of children and adolescents who may be more likely to have RAS.

- Some experts will do a more extensive evaluation for RAS in children and adolescents with stage 2 HTN, those with significant diastolic HTN (especially on ABPM), those with HTN and hypokalemia on screening laboratories, and those with a notable size discrepancy between the kidneys on standard ultrasound imaging.

- Bruits over the renal arteries are also suggestive of RAS but are not always present.

- Consultation with a subspecialist is recommended to decide which patients warrant further investigation & to aid in the selection of the appropriate imaging modality.
Renal Ultrasonography

- **Sensitivity**: 64% to 90%. **Specificity** of 68% to 70%.

- Factors that may affect the accuracy of Doppler ultrasonography include patient cooperation, the technician’s experience, the age of the child, and the child’s BMI.

- Best results are obtained in older (≥8 years), nonobese (BMI ≤85th percentile), cooperative children and adolescents who are examined in a facility with extensive pediatric vascular imaging experience.

**Key Action**

- Doppler renal ultrasonography may be used as a noninvasive screening study for the evaluation of possible RAS in normal-weight children and adolescents ≥8 years of age who are suspected of having renovascular HTN & will cooperate with the procedure.
Cross-sectional data have suggested a relationship between elevated serum uric acid (UA) levels and HTN.

These findings suggest that the ↑UA levels may be viewed as 1 component of CV risk assessment, especially in those with obesity.

A causative role for ↑UA in childhood HTN has not been established.

There is currently not sufficient evidence to support the routine measurement of serum UA in the evaluation and management of children with elevated BP.
Microalbuminuria

- Microalbuminuria (MA), which should be differentiated from proteinuria in CKD, has been shown to be a marker of HTN-related kidney injury and a predictor of CVD in adults.
- MA has been shown to be effectively reduced via the use of ARBs and ACE inhibitors in adults. Lowering the degree of MA in adults has been associated with decreased CVD risk.
- In contrast, data to support a clear relationship between HTN and MA in pediatric patients with primary HTN are limited.
- MA appears to be a nonspecific finding in children that can occur in the absence of HTN; it can occur in children who have obesity, insulin resistance, diabetes, dyslipidemia, and even in those who have recently participated in vigorous physical activity.

**Key Action**
- Routine testing for MA is not recommended for children & adolescents with primary HTN
Algoritmo del manejo diagnóstico y terapéutico de la HTA pediátrica

1. PAS y/o PAD
   - < percentil 90
   - ≥ percentil 90
     - Normotensión
       - Repetir medidas
     - < percentil 90
     - percentil 90-95
     - > percentil 95
       - PA NORMAL-ALTA
         - Seguimiento
         - Repetir medidas
       - HIPERTENSIÓN
         - Evaluar etiología y daño orgánico
           - Una o más de las siguientes condiciones:
             - Falta de respuesta al tratamiento no farmacológico
             - HTA secundaria
             - HTA sintomática
             - Daño orgánico (lesión en órgano diana)
             - HTA estadio 2 (PA > P99 + 5 mmHg)
             - Diabetes, dislipemia, enfermedad renal
             - Crisis hipertensiva

2. NO
   - Tratamiento no farmacológico

3. Sí
   - Tratamiento farmacológico (y no farmacológico)
Overall Goals

- To achieve a BP level that not only reduces the risk for target organ damage in childhood but also reduces the risk for HTN and related CVD in adulthood.

- Several studies have shown that currently available treatment options can even reverse target organ damage in hypertensive youth.

- The previous recommendations for HTN treatment target in children without CKD or diabetes were SBP and DBP <95th percentile. Evidence has emerged that markers of target organ damage, such as increased LVMI, can be detected among some children with BP >90th percentile (or >120/80 mm Hg) but <95th percentile.

- Therefore, an optimal BP level to be achieved with treatment of childhood HTN is <90th percentile or <130/80 mm Hg in ≥13 years old.
Lifestyle and Nonpharmacologic Interventions

- **Lifestyle interventions are recommended to lower BP.**
- There is **good evidence** from studies in adults showing that **nutritional interventions lower BP**, including clinical trials demonstrating that:
  - **reducing dietary sodium** results in lower BP and CV mortality
  - A diet high in **olive oil polyphenols** lowers BP.
- Studies of hypertensive **youth** suggest that the relationship between **diet, physical activity**, & BP in childhood is similar to adults.
**Lifestyle and Nonpharmacologic Interventions: Diet**

- The Dietary Approaches to Stop Hypertension (DASH) approach and specific elements of that diet have been the primary dietary strategy tested in the literature.

- These elements include a diet that is high in fruits, vegetables, lowfat milk products, whole grains, fish, poultry, nuts, and lean red meats; it also includes a limited intake of sugar and sweets along with lower sodium intake.

- Cross-sectional studies demonstrate associations between the DASH diet & BP.

- Population-based data from NHANES show correlations between dietary sodium and BP in childhood, particularly with excess weight.

- A high intake of fruits, vegetables, and legumes is associated with lower BP. A lack of fruit consumption in childhood has been linked to increases in cIMT in young adulthood in the Young Finns study. Higher intake of low-fat dairy products has been associated with lower BP in childhood.

- Longitudinal, observational, and interventional data – The National Heart Lung & Blood Institute’s Growth & Health Study also support relationships between diet & BP in youth.
# DASH Diet Recommendations

<table>
<thead>
<tr>
<th>Food</th>
<th>Servings per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits and vegetables</td>
<td>4–5</td>
</tr>
<tr>
<td>Low-fat milk products</td>
<td>≥2</td>
</tr>
<tr>
<td>Whole grains</td>
<td>6</td>
</tr>
<tr>
<td>Fish, poultry, and lean red meats</td>
<td>≤2</td>
</tr>
<tr>
<td>Legumes and nuts</td>
<td>1</td>
</tr>
<tr>
<td>Oils and fats</td>
<td>2–3</td>
</tr>
<tr>
<td>Added sugar and sweets (including sweetened beverages)</td>
<td>≤1</td>
</tr>
<tr>
<td>Dietary sodium</td>
<td>&lt;2300 mg per d</td>
</tr>
</tbody>
</table>
Physical activity and sedentary behavior thresholds for identifying childhood hypertension and its phenotypes

The Healthy Growth Study

Journal of the American Society of Hypertension
2018

2473 school children aged 9-13 years

Physical activity is inversely associated with all hypertension phenotypes, whereas sedentary behavior is positively associated with ISH and SDH in boys.
TREATMENT

Lifestyle & Nonpharmacologic Interventions: Physical Activity

- Any type of exercise, whether it’s aerobic training, resistance training, or combined training, appears to be beneficial.

**Key Action**
- At the time of diagnosis of elevated BP or HTN in a child or adolescent, clinicians should provide advice on the DASH diet and recommend moderate to vigorous physical activity at least 3 to 5 days per week (30–60 minutes per session) to help reduce BP.
Pharmacologic Treatment

- Children who remain hypertensive despite lifestyle modifications
- Symptomatic HTN
- Stage 2 HTN without a clearly modifiable factor (eg, obesity),
- Any stage of HTN associated with CKD or diabetes mellitus

- Initiate therapy with a single medication at the low end of the dosing range.

- Depending on repeated BP measurements, the dose of the initial medication can be increased every 2 to 4 weeks until:
  - BP is controlled (eg, <90th percentile)
  - the maximal dose is reached
  - or adverse effects occur

- If BP is not controlled with a single agent, a second agent can be added to the regimen and titrated as with the initial drug.

- Because of the salt and water retention that occurs with many antihypertensive medications, a thiazide diuretic is often the preferred second agent.
### Recommendations for the Initial Prescription of Antihypertensive Drugs for Outpatient Management of Chronic HTN

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age</th>
<th>Initial Dose</th>
<th>Maximal Dose</th>
<th>Dosing Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACE inhibitors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benazepril</td>
<td>≥ 6 yᵃ</td>
<td>0.2 mg/kg per d (up to 10 mg per d)</td>
<td>0.6 mg/kg per d (up to 40 mg per d)</td>
<td>Daily</td>
</tr>
<tr>
<td>Captopril</td>
<td>Infants</td>
<td>0.05 mg/kg per dose</td>
<td>6 mg/kg per d</td>
<td>Daily to 4 times a day</td>
</tr>
<tr>
<td></td>
<td>Children</td>
<td>0.5 mg/kg per dose</td>
<td>6 mg/kg per d</td>
<td>Three times a day</td>
</tr>
<tr>
<td>Enalapril</td>
<td>≥ 1 moᵃ</td>
<td>0.08 mg/kg per d (up to 5 mg per d)</td>
<td>0.6 mg/kg per d (up to 40 mg per d)</td>
<td>Daily to twice a day</td>
</tr>
<tr>
<td>Fosinopril</td>
<td>≥ 6 y</td>
<td>0.1 mg/kg per d (up to 5 mg per d)</td>
<td>40 mg per d</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>&lt;50 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 50 kgᵇ</td>
<td>5 mg per d</td>
<td>40 mg per d</td>
<td>Daily</td>
</tr>
<tr>
<td>Lisinopril</td>
<td>≥ 6 yᵃ</td>
<td>0.07 mg/kg per d (up to 5 mg per d)</td>
<td>0.8 mg/kg per d (up to 40 mg per d)</td>
<td>Daily</td>
</tr>
<tr>
<td>Ramipril</td>
<td>—</td>
<td>1.6 mg/m² per d</td>
<td>6 mg/m² per d</td>
<td>Daily</td>
</tr>
<tr>
<td>Quinapril</td>
<td>—</td>
<td>5 mg per d</td>
<td>80 mg per d</td>
<td>Daily</td>
</tr>
</tbody>
</table>

| **ARBs** |             |                              |                              |                 |
| Candesartan | 1–5 yᵇ     | 0.02 mg/kg per d (up to 4 mg per d) | 0.4 mg/kg per d (up to 16 mg per d) | Daily to twice a day |
|         | ≥ 6 yᵃ      |                              |                              |                 |
|         | <50 kg      | 4 mg per d                   | 16 mg per d                  |                 |
|         | ≥ 50 kgᵇ    | 8 mg per d                   | 32 mg per d                  |                 |
| Irbesartan | 6–12 y      | 75 mg per d                  | 150 mg per d                 | Daily           |
|         | ≥ 15        | 150 mg per d                 | 300 mg per d                 |                 |
| Losartan  | ≥ 6 yᵃ      | 0.7 mg/kg (up to 50 mg)      | 1.4 mg/kg (up to 100 mg)     | Daily           |
| Olmesartan | ≥ 6 yᵃ     | —                            | —                            | Daily           |
|         | <35 kg      | 10 mg                        | 20 mg                        |                 |
|         | ≥35 kgᵇ     | 20 mg                        | 40 mg                        |                 |
| Valsartan | ≥ 6 yᵃ      | 1.3 mg/kg (up to 40 mg)      | 2.7 mg/kg (up to 160 mg)     | Daily           |
Recommendations for the Initial Prescription of Antihypertensive Drugs for Outpatient Management of Chronic HTN

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age</th>
<th>Initial Dose</th>
<th>Maximal Dose</th>
<th>Dosing Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thiazide diuretics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contraindications: anuria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common adverse effects: dizziness, hypokalemia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe adverse effects: cardiac dysrhythmias, cholestatic jaundice, new onset diabetes mellitus, pancreatitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorothalidone</td>
<td>Child</td>
<td>0.3 mg/kg</td>
<td>2 mg/kg per d (50 mg)</td>
<td>Daily</td>
</tr>
<tr>
<td>Chlorothiazide</td>
<td>Child</td>
<td>10 mg/kg per d</td>
<td>20 mg/kg per d (up to 375 mg per d)</td>
<td>Daily to twice a day</td>
</tr>
<tr>
<td>Hydrochlorothiazide</td>
<td>Child</td>
<td>1 mg/kg per d</td>
<td>2 mg/kg per d (up to 37.5 mg per d)</td>
<td>Daily to twice a day</td>
</tr>
<tr>
<td><strong>Calcium channel blockers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contraindications: hypersensitivity to CCBs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common adverse effects: flushing, peripheral edema, dizziness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe adverse effects: angioedema</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amlodipine</td>
<td>1–5 y</td>
<td>0.1 mg/kg</td>
<td>0.6 mg/kg (up to 5 mg per d)</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>≥6 y</td>
<td>2.5 mg</td>
<td>10 mg</td>
<td>Daily</td>
</tr>
<tr>
<td>Felodipine</td>
<td>≥6 y</td>
<td>2.5 mg</td>
<td>10 mg</td>
<td>Daily</td>
</tr>
<tr>
<td>Isradipine</td>
<td>Child</td>
<td>0.05–0.1 mg/kg</td>
<td>0.6 mg/kg (up to 10 mg per d)</td>
<td>Capsule: twice daily to 3 times a day; extended-release tablet: daily</td>
</tr>
<tr>
<td>Nifedipine extended release</td>
<td>Child</td>
<td>0.2–0.5 mg/kg per d</td>
<td>3 mg/kg/d (up to 120 mg per d)</td>
<td>Daily to twice a day</td>
</tr>
</tbody>
</table>
Pharmacologic Treatment: *Choice of Agent*

- Pharmacologic treatment of HTN in children and adolescents should be initiated with an ACE inhibitor, ARB, long-acting calcium channel blocker, or a thiazide diuretic.

- In view of the expanded adverse effect profile and lack of association in adults with improved outcomes compared with other agents, β-blockers are not recommended as initial treatment in children.

- **ACE inhibitors and ARBs are contraindicated in pregnancy** because these agents can cause injury and death to the developing fetus. Adolescents of childbearing potential should be informed of the potential risks of these agents on the developing fetus; alternative medications (eg, calcium channel blocker, β-blocker) can be considered when appropriate.

- In children with HTN and CKD, proteinuria, or diabetes mellitus, an ACE inhibitor or ARB is recommended as the initial antihypertensive agent unless there is an absolute contraindication.

- **Other antihypertensive medications** (eg, α-blockers, β-blockers, combination α-and β-blockers, centrally acting agents, potassium-sparing diuretics, and direct vasodilators) should be reserved for children who are not responsive to ≥2 of the preferred agents.
**TREATMENT: Follow-Up and Monitoring**

- Treatment of a child or adolescent with HTN requires ongoing monitoring because **goal BP can be difficult to achieve**.

- **If the decision has been made to initiate treatment with medication**, the patient should be seen frequently (**every 4–6 weeks**) for dose adjustments and/or addition of a second or third agent until goal BP has been achieved. After that, the frequency of visits can be extended to **every 3 to 4 months**.

- **If the decision has been made to proceed with lifestyle changes only**, then follow-up visits can occur at longer intervals (**every 3–6 months**) so that adherence to lifestyle change can be reinforced and the need for initiation of medication can be reassessed.

- At each follow-up visit, the patient should be assessed for **adherence** and for any **adverse effects** of the prescribed medication; such assessment may **include laboratory testing** depending on the medication (for example, electrolyte monitoring if the patient is on a diuretic). It is also important to **continually reinforce adherence to lifestyle changes** because effective treatment will depend on the combination of effects from both medication and lifestyle measures.

- Finally, known hypertensive **target organ damage (such as LVH)** should be reassessed according to the recommendations.
Resistant HTN in adults is defined as persistently elevated BP despite treatment with 3 or more antihypertensive agents of different classes. All of these drugs should be prescribed at maximally effective doses, and at least 1 should be a diuretic.

Key to the identification of patients with true resistant HTN is correct office BP measurement, confirmation of adherence to current therapy, and confirmation of treatment resistance by ABPM.

The treatment of patients with resistant HTN includes dietary sodium restriction, the elimination of substances known to elevate BP, the identification of previously undiagnosed secondary causes of HTN, the optimization of current therapy, and the addition of additional agents as needed.

Recent clinical trial data suggest that an aldosterone receptor antagonist (such as spironolactone) is the optimal additional agent in adults with resistant HTN; it helps address volume excess as well as untreated hyperaldosteronism, which is common in adult patients with true resistant HTN.

At present, there are no data on if true treatment-resistant HTN exists in pediatric patients.
Children and adolescents with CKD often present with or develop HTN.

HTN is a known risk factor for the progression of kidney disease in adults and children. Evidence suggests that the treatment of HTN in children with CKD might slow the progression of or reverse end organ damage.

When evaluated by 24-hour ABPM, children and adolescents with CKD often have poor BP control even if BP measured in the clinic appears to be normal.

MH is associated with end organ damage, such as LVH.

Threshold values that define HTN are not different in children with CKD, although there is some evidence that lower treatment goals might improve outcomes.
Children & adolescents with CKD should be evaluated for HTN at each medical encounter.

Children or adolescents with both CKD and HTN should be treated to lower 24-hour MAP to <50th percentile by ABPM.

Regardless of apparent control of BP with office measures, children and adolescents with CKD and a history of HTN should have BP assessed by ABPM at least yearly to screen for MH.
Proteinuric renal disease is often associated with HTN and a rapid decline in glomerular filtration.

Studies in both adults and children have indicated that both BP control and a reduction in proteinuria are beneficial for preserving renal function.

RAAS blockade therapy in patients with CKD & HTN has been shown to benefit both BP & proteinuria. The benefit of such therapy may not be sustained, however.

Key Action
- Children and adolescents with CKD & HTN should be evaluated for proteinuria.

Key Action
- Children and adolescents with CKD, HTN, & proteinuria should be treated with: an ACE inhibitor or ARB.
Children and adolescents with T1DM or T2DM should be evaluated for HTN at each medical encounter and treated if BP is ≥95th percentile or >130/80 mm Hg in adolescents ≥13 years of age.
Comorbidities

- **Dyslipidemia**
  Children and adolescents with HTN are at increased risk for lipid disorders attributable to the “common soil” phenomenon, in which poor diet, inactivity, and obesity contribute to both disorders. HTN and dyslipidemias are associated with subclinical atherosclerosis and are risk factors for future CVD.

- **OSAS**
  Children with moderate to severe OSAS are at increased risk for HTN. However, it is not known whether OSAS treatment with continuous positive airway pressure results in improved BP in all children. Furthermore, adenotonsillectomy may not result in BP improvement in all children with OSAS.

- **Cognitive Impairment**
  The central nervous system is a target organ that can be affected by HTN.
**Acute Severe HTN**

- **There is a lack of robust evidence** to guide the evaluation and management of children and adolescents with acute presentations of severe HTN. Thus, much of what is known is derived from studies conducted in adults, including medication choice.

- Although children and adolescents can become symptomatic from HTN at lesser degrees of BP elevation, in general, patients who present with acute severe HTN will have BP elevation well above the stage 2 HTN threshold.

- The major clinical issue in such children is that this level of BP elevation may produce **acute target organ effects**, including encephalopathy, acute kidney injury, & congestive heart failure. Clinicians should be concerned about these complications when a child’s BP increases 30 mm Hg or more above the 95th percentile.

- Although a few children with primary HTN may present with features of acute severe HTN, the vast majority will have an underlying secondary cause of HTN. Thus, for patients who present with acute severe HTN, an evaluation for secondary causes is appropriate & should be conducted expediently.
Given the potential for the development of potentially lifethreatening complications, children & adolescents who present with acute severe HTN require immediate treatment with short-acting antihypertensive medications that may abort such sequelae.

Treatment may be initiated with oral agents if the patient is able to tolerate oral therapy and if life-threatening complications have not yet developed.

Intravenous agents are indicated when oral therapy is not possible because of the patient’s clinical status or when a severe complication has developed (such as congestive heart failure) that warrants a more controlled BP reduction.

The BP should be reduced by no more than 25% of the planned reduction over the first 8 hours, with the remainder of the planned reduction over the next 12 to 24 hours.

The ultimate short-term BP goal in such patients should be around the 95th percentile.
**Oral & IV Antihypertensive Medications for Acute Severe HTN**

### Usefu for Severely Hypertensive Patients With Life-Threatening Symptoms

<table>
<thead>
<tr>
<th>Drug</th>
<th>Class</th>
<th>Dose</th>
<th>Route</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esmolol</td>
<td>β-adrenergic blocker</td>
<td>100–500 µg/kg per min</td>
<td>Intravenous infusion</td>
<td>Short acting, constant infusion preferred. May cause profound bradycardia</td>
</tr>
<tr>
<td>Hydralazine</td>
<td>Direct vasodilator</td>
<td>0.1–0.2 mg/kg per dose up to 0.4 mg/kg per dose</td>
<td>Intravenous, intramuscular</td>
<td>Causes tachycardia</td>
</tr>
<tr>
<td>Labetalol</td>
<td>α- and β-adrenergic blocker</td>
<td>Bolus: 0.20–1.0 mg/kg per dose up to 40 mg per dose Infusion: 0.25–3.0 mg/kg per h</td>
<td>Intravenous bolus or infusion</td>
<td>Asthma and overt heart failure are relative contraindications</td>
</tr>
<tr>
<td>Nicardipine</td>
<td>Calcium channel blocker</td>
<td>Bolus: 0.30 µg/kg up to 2 mg per dose Infusion: 0.5–4 µg/kg per min</td>
<td>Intravenous bolus or infusion</td>
<td>May cause reflex tachycardia. Increases cyclosporine and tacrolimus levels</td>
</tr>
<tr>
<td>Sodium nitroprusside</td>
<td>Direct vasodilator</td>
<td>Starting: 0–3 µg/kg per min Maximum: 10 µg/kg per min</td>
<td>Intravenous infusion</td>
<td>Monitor cyanide levels with prolonged (&gt;72 h) use or in renal failure; or coadminister with sodium thiosulfate</td>
</tr>
</tbody>
</table>

### Useful for Severely Hypertensive Patients With Less Significant Symptoms

<table>
<thead>
<tr>
<th>Drug</th>
<th>Class</th>
<th>Dose</th>
<th>Route</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clonidine</td>
<td>Central α-agonist</td>
<td>2–5 mg/kg per dose up to 10 mg/kg per dose given every 6–8 h</td>
<td>Oral</td>
<td>Adverse effects include dry mouth and drowsiness</td>
</tr>
<tr>
<td>Fenoldopam</td>
<td>Dopamine receptor agonist</td>
<td>0.2–0.5 mg/kg per min up to 0.8 mg/kg per min</td>
<td>Intravenous infusion</td>
<td>Higher doses worsen tachycardia without further reducing BP</td>
</tr>
<tr>
<td>Hydralazine</td>
<td>Direct vasodilator</td>
<td>0.25 mg/kg per dose up to 20 mg per dose given every 6–8 h</td>
<td>Oral</td>
<td>Half-life varies with genetically determined acetylation rates</td>
</tr>
<tr>
<td>Isradipine</td>
<td>Calcium channel blocker</td>
<td>0.05–0.1 mg/kg per dose up to 5 mg per dose given every 6–8 h</td>
<td>Oral</td>
<td>Exaggerated decrease in BP can be seen in patients receiving azole antifungal agents</td>
</tr>
<tr>
<td>Minoxidil</td>
<td>Direct vasodilator</td>
<td>0.1–0.2 mg/kg per dose up to 10 mg per dose given every 8–12 h</td>
<td>Oral</td>
<td>Most potent oral vasodilator; long acting</td>
</tr>
</tbody>
</table>
In adults, physical fitness is associated with lower all-cause mortality.

On the basis of adult evidence, sports participation should improve BP over time. Additionally, exercise itself has a beneficial effect on cardiac structure in adolescents.

The athlete interested in participating in competitive sports and/or intense training presents a special circumstance.

**Recommendations from AHA and ACC** include:

1. limiting competitive athletic participation among athletes with **LVH** beyond that seen with athlete’s heart until **BP is normalized** by antihypertensive drug therapy.
2. restricting athletes with **stage 2 HTN** from participating in **high-static sports** (eg, weight lifting, boxing, and wrestling) until **HTN is controlled**.

There are no data linking the presence of **HTN to sudden death related to sports participation** in children, although many cases of sudden death are of unknown etiology.
HTN is common in children after solid-organ transplants: 50% to 90%

- **Contributing factors** include the use of steroids, calcineurin inhibitors, & mTOR inhibitors.
- In patients with renal transplants, the presence of native kidneys, CKD, and transplant glomerulopathy are additional risk factors for HTN.
  - HTN rates are higher by 24-hour ABPM compared with clinic BP measurements because these populations commonly have MH & nocturnal HTN.
  - The management of identified HTN in the pediatric transplant patient can be challenging. Rates of control of HTN in renal-transplant patients generally range from 33% to 55%.
  - Limited evidence that ACE inhibitors and ARBs may be superior in achieving BP control and improving long-term graft survival in renal-transplant patients.
  - The combination of ACE inhibitors and ARBs in renal-transplant patients has been associated with acidosis & hyperkalemia → not recommended.
Adolescents with elevated BP or HTN should have:
- care transitioned to an adult care provider by 22 years of age

Transfer of information of the patient:
- HTN etiology
- past manifestations
- complications
**Prevention of HTN : Importance**

- Elevated BP measurements in childhood confers an increased risk of adult HTN.
- ↑BMI is a major determinant of the development of HTN.
- In both children and adults, efforts should be made to prevent progression to sustained HTN and to avoid the development of hypertensive CV diseases.

**Prevention of HTN : Strategies**

- Prevention efforts to date have focused on *lifestyle modification, especially dietary intervention, exercise, and treatment of obesity.*
- **Appropriate energy balance**: calories eaten balanced by calories expended in physical activity → the best strategy to maintain an appropriate BMI & avoid obesity.
- 60 min/day of moderate to vigorous *physical activity*
- Normal sleep habits & avoidance of tobacco are also strategies to reduce CV risk.
Flynn JT, Kaelber DC, Baker-Smith CM, et al. 
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