

High Blood Pressure in Pediatrics

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Objectives

- **Review AAP 2017 Clinical Practice Guidelines for Screening and Management of High Blood Pressure in Children and Adolescents** (update from the 2004 Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents)
- Foster a patient- and family-centered approach to care, reduce unnecessary and costly medical interventions, improve patient diagnoses and outcomes, support implementation, and provide direction for future research.

8 Significant Changes in 2017 Guidelines

- Replacement of the term “prehypertension” with the term “elevated blood pressure”
- New normative pediatric blood pressure (BP) tables based on normal-weight children
- Simplified screening table for identifying BPs needing further evaluation
- Simplified BP classification in adolescents ≥ 13 years of age that aligns with the AHA and ACC adult BP guidelines
- More limited recommendation to perform screening BP measurements only at preventive care visits
- Streamlined recommendations on the initial evaluation and management of abnormal BPs
- An expanded role for ambulatory BP monitoring in the diagnosis and management of pediatric hypertension
- Revised recommendations on when to perform echocardiography in the evaluation of newly diagnosed hypertensive pediatric patients and a revised definition of LVH

2017 Guidelines

- 30 Key Action Statements (level of evidence, benefit-harm relationship, and strength of recommendation)
- 27 additional recommendations based on the consensus expert opinion of the subcommittee members
- Endorsed by AHA

**Aggregate
Evidence Quality**

**Benefit or Harm
Predominates**

**Benefit and Harm
Balanced**

Level A

Intervention: Well-designed and conducted trials, meta-analyses on applicable populations
Diagnosis: Independent gold standard studies of applicable populations

**Strong
Recommendation**

**Weak
Recommendation
(based on balance of
benefit and harm)**

Level B

Trials or diagnostic studies with minor limitations; consistent findings from multiple observational studies

**Moderate
Recommendation**

Level C

Single or few observational studies or multiple studies with inconsistent findings or major limitations.

**Weak
Recommendation
(based on low quality
evidence)**

**No
recommendation
may be made**

Level D

Expert opinion, case reports, reasoning from first principles

Level X

Exceptional situations where validating studies cannot be performed and benefit or harm clearly predominates

**Strong
Recommendation**
**Moderate
Recommendation**

Prevalence of High BP

- Increasing prevalence of childhood high BP (both HTN and elevated BP.)
- Boys (15%–19%) > girls (7%–12%)
- Hispanics and non-Hispanic African Americans > non-Hispanic white children
- Adolescents > younger children

**Based on NHANES*

Prevalence of High BP

continued

- *In a clinical setting and with repeated BP measurements*, the prevalence of confirmed HTN is lower in part because of
 - inherent BP variability
 - accommodation effect
- Actual prevalence of **clinical HTN**: ~3.5%
- Actual prevalence of **persistently elevated BP (formerly “preHTN”)** : ~2.2% to 3.5%
- Higher rates among children and adolescents who are overweight (\geq 85th - <95th percentile BMI) and obese (\geq 95th percentile BMI)

Why Do We Care?

- Higher BP in childhood -> higher BP in adulthood and the onset of HTN in young adulthood.
- The strength of the tracking relationship is stronger in older children and adolescents.
- Normal BP in childhood is associated with a lack of HTN in mid-adulthood.

Ignorance is Bliss?

- Of the 32.6% of US adults who have HTN, almost half (17.2%) are not aware they have HTN.
- Among those who are aware of their condition, only approximately half (54.1%) have controlled BP.
- No similar large studies looking at awareness of childhood HTN
- The SEARCH for Diabetes in Youth study:
 - only 7.4% of youth with type 1 diabetes mellitus (T1DM) and 31.9% of youth with type 2 diabetes mellitus (T2DM) demonstrated knowledge of their BP status.
 - Even after becoming aware of the diagnosis, only 57.1% of patients with T1DM and 40.6% of patients with T2DM achieved good BP control

Chronic Conditions Associated with HTN in Children?

Chronic Conditions Associated with HTN in Children

- Obesity
- Sleep-disordered breathing (SDB)
- CKD
- Prematurity

Children and Obesity

- HTN prevalence ranges from 3.8% to 24.8% in youth with overweight and obesity
- Rates of HTN increase as adiposity and weight circumference increases
- 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.
- Childhood obesity is related to the development of future HTN (*correlation starting as early as infancy*)
- Risk of HTN increases with obesity severity compared with normal weight children and adolescents:
 - 4x increase in those with severe obesity (BMI >99th percentile)
 - 2x increase in those with obesity (BMI 95th–98th percentiles)

Children with Sleep Disordered Breathing (SDB)

- Spectrum includes (1) primary snoring, (2) sleep fragmentation, and (3) obstructive sleep apnea syndrome (OSAS)
- Children who sleep 7 hours or less per night are at increased risk for HTN
- Prevalence of high BP ranges between 3.6% and 14%.
- The more severe the OSAS, the more likely a child is to have HTN.
- Inadequate duration of sleep and poor-quality sleep have been associated with elevated BP.

Children and CKD

- 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, with 20% to 70% having uncontrolled HTN.
- Almost 20% of pediatric HTN may be attributable to CKD.

Children with H/o Prematurity

- Data limited
- Preterm birth and low birth weight have been identified as a risk factor for HTN and other CVD in adults
- 2/2 abnormal circadian BP patterns in childhood?
- One retrospective cohort study showed a prevalence of HTN of 7.3% among 3 year olds who were born preterm.
- Another retrospective case series noted a high prevalence of HTN in older children with a history of preterm birth.

Why do We Care?

- Elevated BP in childhood increases the risk for adult HTN and metabolic syndrome.
- Higher BP levels in childhood -> more likely to have persistent HTN as adults.
- Young patients with HTN are likely to experience accelerated vascular aging (increased LVM, carotid intimamedia thickness)

Adult CV Starts in Childhood: Life's Simple 7

- AHA identified *key contributors to CV health*
- 4 ideal health behaviors
 - not smoking
 - normal BMI
 - physical activity at goal levels
 - healthy diet
- 3 ideal health factors
 - untreated, normal total cholesterol
 - normal fasting blood glucose
 - normal untreated BP (\leq 90th percentile or $<120/80$ mmHg).

Sad Facts:

- One third of US adolescents report having tried a cigarette in the past 30 days.
- Almost half (40%–48%) of teenagers have elevated BMI.
- The rates of severe obesity (BMI >99th percentile) continue to climb, particularly in girls and adolescents.
- Less than half of school-aged boys and only one-third of school-aged girls meet the goal for ideal physical activity levels.
- More than 80% of youth 12 to 19 years of age have a poor diet. (~10% eat adequate fruits and vegetables, ~15% consume <1500 mg per day of sodium)

So We Care Because

- Measuring BP at WCC enables the early detection of primary HTN and the detection of asymptomatic HTN secondary to another underlying disorder
- Greater relative prevalence of secondary causes of HTN in children compared with adults.

*CVD begins in childhood!

HTN Definitions (1-18yo)

- Age, height and gender
- Based on auscultation (vs oscillometric or ABPM readings)

HTN Definitions for Pediatrics

	Old	New For Children Aged 1– <13 y	New For Children Aged ≥13 y
Normal BP	SBP and DBP <90th percentile	SBP and DBP <90th percentile	<120/<80 mmHg
Preadolescent preHTN (elevated BP)	SBP and/or DBP ≥90th percentile and <95th percentile	≥90th percentile to <95th percentile or 120/80 mmHg to <95th percentile (whichever is lower)	
Adolescent preHTN (elevated BP)	SBP and/or DBP ≥120/80 mm Hg to <95th percentile, or ≥90th and <95th percentile, whichever was lower		120/<80 to 129/<80 mmHg
Stage 1 HTN	SBP and/or DBP ≥95th percentile + 5 mm Hg	≥95th percentile to ≥95th percentile + 12 mmHg, or 130/80 to 139/89 mmHg (whichever is lower)	130/80 to 139/89 mmHg
Stage 2 HTN	SBP and/or DBP ≥95th percentile + 5 mmHg	≥95th percentile + 12 mm Hg, or ≥140/90 mm Hg (whichever is lower)	≥140/90 mm Hg

Current Definitions of Pediatric BPs

TABLE 3 Updated Definitions of BP Categories and Stages

For Children Aged 1–<13 y	For Children Aged ≥13 y
Normal BP: <90th percentile	Normal BP: <120/<80 mm Hg
Elevated BP: ≥90th percentile to <95th percentile or 120/80 mm Hg to <95th percentile (whichever is lower)	Elevated BP: 120/<80 to 129/<80 mm Hg
Stage 1 HTN: ≥95th percentile to <95th percentile + 12 mmHg, or 130/80 to 139/89 mm Hg (whichever is lower)	Stage 1 HTN: 130/80 to 139/89 mm Hg
Stage 2 HTN: ≥95th percentile + 12 mm Hg, or ≥140/90 mm Hg (whichever is lower)	Stage 2 HTN: ≥140/90 mm Hg

New BP Tables

- Based on auscultatory measurements obtained from ~50,000 children and adolescents
- Still 4 categories: normal (50th percentile), elevated BP (>90th percentile), stage 1 HTN (≥ 95 th percentile), and stage 2 HTN (≥ 95 th percentile + 12 mmHg).
- **Actual heights** in centimeters and inches are provided (not just percentiles)
- Only normal weight children included (<85% BMI)
- New, simplified table for **BP screening**

New Boys BP Table

BP Levels for Boys by Age and Height Percentile

Age (y)	BP Percentile	SBP (mmHg)							DBP (mmHg)						
		Height Percentile or Measured Height							Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (in)	30.4	30.8	31.6	32.4	33.3	34.1	34.6	30.4	30.8	31.6	32.4	33.3	34.1	34.6
	Height (cm)	77.2	78.3	80.2	82.4	84.6	86.7	87.9	77.2	78.3	80.2	82.4	84.6	86.7	87.9
	50th	85	85	86	86	87	88	88	40	40	40	41	41	42	42
	90th	98	99	99	100	100	101	101	52	52	53	53	54	54	54
	95th	102	102	103	103	104	105	105	54	54	55	55	56	57	57
	95th + 12 mm Hg	114	114	115	115	116	117	117	66	66	67	67	68	69	69
2	Height (in)	33.9	34.4	35.3	36.3	37.3	38.2	38.8	33.9	34.4	35.3	36.3	37.3	38.2	38.8
	Height (cm)	86.1	87.4	89.6	92.1	94.7	97.1	98.5	86.1	87.4	89.6	92.1	94.7	97.1	98.5
	50th	87	87	88	89	89	90	91	43	43	44	44	45	46	46
	90th	100	100	101	102	103	103	104	55	55	56	56	57	58	58
	95th	104	105	105	106	107	107	108	57	58	58	58	59	61	61
	95th + 12 mm Hg	116	117	117	118	119	120	121	69	70	70	70	71	73	73

Simplified Screening BP Table

TABLE 6 Screening BP Values Requiring Further Evaluation

Age, y	BP, mm Hg			
	Boys		Girls	
	Systolic	DBP	Systolic	DBP
1	98	52	98	54
2	100	55	101	58
3	101	58	102	60
4	102	60	103	62
5	103	63	104	64
6	105	66	105	67
7	106	68	106	68
8	107	69	107	69
9	107	70	108	71
10	108	72	109	72
11	110	74	111	74
12	113	75	114	75
≥13	120	80	120	80

Diagnosing elevated BP begins with Correct Measurements

- BP measurements can vary between and within visits
- Factors that can influence BP: caffeine, anxiety
- Need multiple measurements OVER TIME to dx elevated BP

Correct BP Measurements in Kiddos

TABLE 7 Best BP Measurement Practices

1. 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.
2. 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.
3. The correct cuff size should be used. The bladder length should be 80%–100% of the circumference of the arm, and the width should be at least 40%.
4. 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.
5. To measure BP in the legs, the patient should be in the prone position, if possible. An appropriately sized cuff should be placed midthigh and the stethoscope placed over the popliteal artery. The SBP in the legs is usually 10%–20% higher than the brachial artery pressure.

Correct Cuff Sizing

- Many offices lack sufficient cuff sizes (up to thigh cuffs)
- For children in whom the appropriate cuff size is difficult to determine, the midarm circumference (measured as the midpoint between the acromion of the scapula and olecranon of the elbow, with the shoulder in a neutral position and the elbow flexed to 90 °) should be obtained for an accurate determination of the correct cuff size



What If the Initial BP is elevated?

- Take 2 additional oscillometric or auscultatory BP measurements at the same visit and average them.
- Avg auscultatory BP -> categorize based on table
- If oscillometric avg \geq 90th percentile, 2 auscultatory measurements should be taken and averaged to define the BP category.



How Often Should We Check BP in Pediatric Patients?

Key Action Statement 1

BP should be measured annually in children and adolescents ≥ 3 years of age (grade C, moderate recommendation).

Key Action Statement 2

BP should be checked in all children and adolescents ≥ 3 years of age at every health care encounter if they have obesity, are taking medications known to increase BP, have renal disease, a history of aortic arch obstruction or coarctation, or diabetes (grade C, moderate recommendation).

TABLE 8 Common Pharmacologic Agents Associated With Elevated BP in Children

Over-the-counter drugs	Decongestants Caffeine Nonsteroidal anti-inflammatory drugs Alternative therapies, herbal and nutritional supplements
Prescription drugs	Stimulants for attention-deficit/hyperactivity disorder Hormonal contraception Steroids Tricyclic antidepressants
Illicit drugs	Amphetamines Cocaine

Adapted from the Fourth Report.¹

TABLE 9 Conditions Under Which Children Younger Than 3 Years Should Have BP Measured

History of prematurity <32 week's gestation or small for gestational age, very low birth weight, other neonatal complications requiring intensive care, umbilical artery line

Congenital heart disease (repaired or unrepaired)

Recurrent urinary tract infections, hematuria, or proteinuria

Known renal disease or urologic malformations

Family history of congenital renal disease

Solid-organ transplant

Malignancy or bone marrow transplant

Treatment with drugs known to raise BP

Other systemic illnesses associated with HTN (neurofibromatosis, tuberous sclerosis, sickle cell disease,¹¹⁴ etc)

Evidence of elevated intracranial pressure

Adapted from Table 3 in the Fourth Report.¹

Initial Management: Elevated BP

- Recommend lifestyle interventions should be recommended (ie, healthy diet, sleep, and physical activity)
- **6 month BP check** by auscultation
- Nutrition and/or weight management referral should be considered as appropriate

F/u Management: Elevated BP

- If BP remains at the elevated at 6 mo f/u, check BUE and one LE BP, repeat lifestyle counseling, and **BP check in 6 mo** by auscultation
- If BP remains elevated after 12 months (eg, after 3 auscultatory measurements), ABPM should be ordered (if available), 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.*

Initial Management:

Stage 1 HTN

- If pt is asx, provide lifestyle counseling and **recheck BP in 1 to 2 weeks** by auscultation

F/u Management: Stage 1 HTN

- If the BP reading still stage 1 HTN, BUE and one LE BP checked, and BP check in **3 months** by auscultation. Nutrition and/or weight management referral should be considered as appropriate
- If BP continues to be at the stage 1 HTN level after 3 visits, ABPM should be ordered (if available), diagnostic evaluation should be conducted, and treatment should be initiated. Subspecialty referral should be considered

Initial Management:

Stage 2 HTN

- If asx, BUE and one LE BP should be checked, lifestyle recommendations given, and the BP check **within 1 week**.
- Alternatively, refer to subspecialty care within 1 week.

F/u Management: Stage 2 HTN

- If the BP reading is still c/w stage 2 HTN level at f/u, then diagnostic evaluation, including ABPM, should be conducted and treatment should be initiated
- Or refer 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 mmHg above the 95th percentile (or >180/120 mmHg in an adolescent), refer to an immediate source of care, such as an emergency department (ED).***

TABLE 11 Patient Evaluation and Management According to BP Level

BP Category (See Table 3)	BP Screening Schedule	Lifestyle Counseling (Weight and Nutrition)	Check Upper and Lower Extremity BP	ABPM ^a	Diagnostic Evaluation ^b	Initiate Treatment ^c	Consider Subspecialty Referral
Normal	Annual	X	—	—	—	—	—
Elevated BP	Initial measurement	X	—	—	—	—	—
	Second measurement: repeat in 6 mo	X	X	—	—	—	—
	Third measurement: repeat in 6 mo	X	—	X	X	—	X
Stage 1 HTN	Initial measurement	X	—	—	—	—	—
	Second measurement: repeat in 1–2 wk	X	X	—	—	—	—
	Third measurement: repeat in 3 mo	X	—	X	X	X	X
Stage 2 HTN ^d	Initial measurement	X	X	—	—	—	—
	Second measurement: repeat, refer to specialty care within 1 wk	X	—	X	X	X	X

X, recommended intervention; —, not applicable.

^a ABPM is done to confirm HTN before initiating a diagnostic evaluation.

^b See Table 15 for recommended studies.

^c Treatment may be initiated by a primary care provider or subspecialist.

^d If the patient is symptomatic or BP is >30 mm Hg above the 95th percentile (or >180/120 mm Hg in an adolescent), send to an ED.

TABLE 10 Screening Tests and Relevant Populations

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

Adapted from Wiesen J, Adkins M, Fortune S, et al. Evaluation of pediatric patients with mild-to-moderate hypertension: yield of diagnostic testing. *Pediatrics*. 2008;122(5). Available at: www.pediatrics.org/cgi/content/full/122/5/e988.

Key Action Statement 3

Trained health care professionals in the office setting should make a diagnosis of HTN if a child or adolescent has auscultatory confirmed BP readings ≥ 95 th percentile on 3 different visits (grade C, moderate recommendation).

Key Action Statement 4

Organizations with EHRs used in an office setting should consider including flags for abnormal BP values both when the values are being entered and when they are being viewed (grade C, weak recommendation).

Key Action Statement 5

Oscillometric devices may be used for BP screening in children and adolescents. When doing so, providers should use a device that has been validated in the pediatric age group. If elevated BP is suspected on the basis of oscillometric readings, confirmatory measurements should be obtained by auscultation (grade B, strong recommendation).

Ambulatory BP Monitor



ABPM

- More accurate for the diagnosis of HTN than clinic-measured BP
- More predictive of future BP
- Can assist in the detection of secondary HTN.
- Increased LVMI and LVH correlate more strongly with ABPM parameters than casual BP readings.
- More reproducible than casual or home BP measurements

**May require specialist referral*

Key Action Statement 6

ABPM should be performed for the confirmation of HTN in children and adolescents with office BP measurements in the elevated BP category for 1 year or more or with stage 1 HTN over 3 clinic visits (grade C, moderate recommendation).

Key Action Statement 7

The routine performance of ABPM should be strongly considered in children and 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 (grade B, moderate recommendation).

TABLE 12 High-Risk Conditions for Which ABPM May Be Useful

Condition	Rationale
Secondary HTN	Severe ambulatory HTN or nocturnal HTN indicates higher likelihood of secondary HTN ^{161,167}
CKD or structural renal abnormalities	Evaluate for MH or nocturnal HTN, ^{168–172} better control delays progression of renal disease ¹⁷³
T1DM and T2DM	Evaluate for abnormal ABPM patterns, ^{174,175} better BP control delays the development of MA ^{176–178}
Solid-organ transplant	Evaluate for MH or nocturnal HTN, better control BP ^{179–188}
Obesity	Evaluate for WCH and MH ^{23,189–192}
OSAS	Evaluate for nondipping and accentuated morning BP surge ^{43,46,193,194}
Aortic coarctation (repaired)	Evaluate for sustained HTN and MH ^{58,112,113}
Genetic syndromes associated with HTN (neurofibromatosis, Turner syndrome, Williams syndrome, coarctation of the aorta)	HTN associated with increased arterial stiffness may only be manifest with activity during ABPM ^{58,195}
Treated hypertensive patients	Confirm 24-h BP control ¹⁵⁵
Patient born prematurely	Evaluate for nondipping ¹⁹⁶
Research, clinical trials	To reduce sample size ¹⁹⁷

Key Action Statement 8

ABPM should be performed by using a standardized approach with monitors that have been validated in a pediatric population, and studies should be interpreted by using pediatric normative data (grade C, moderate recommendation).

ABPM

- Helps identify Masked HTN (normal office BP but elevated BP on ABPM) and White Coat HTN (WCH)
- MH:
 - Significant risk for end organ hypertensive damage.
 - Patients at risk include patients with obesity and secondary forms of HTN, such as CKD or repaired aortic coarctation.

WCH

- Up to half of children who are evaluated for elevated office BP have WCH
- Abnormal BP response to exercise and increased LVM has been found to occur in children with WCH.
- Identification of WCH may reduce costs (reducing unnecessary testing and decreasing the number of children exposed to antihypertensive medications.)
- 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.

ABPM and Obesity

- Obesity -> increased midarm circumference -> larger BP cuff
- ABPM is a valuable tool in the diagnosis of HTN in children with obesity because of the discrepancies between casual and ambulatory BPs and the higher prevalence of MH.

Home BP Monitoring

- Easy, more reproducible than office BPs
- Only a few automated devices have been validated in peds population
- Limited cuff sizes available
- No consensus regarding how many home measurements across what period of time are needed to evaluate BP

**Can be helpful to monitor treatment but not good for dx*

Key Action Statement 10

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 (grade C, moderate recommendation).

Primary vs Secondary HTN

- Primary HTN = #1 cause of pediatric HTN in the US
- General characteristics of children with primary HTN:
 - older age (≥ 6 years)
 - positive family history (in a parent and/or grandparent) of HTN
 - overweight and/or obesity
- While severity of BP elevation has not differed significantly between children with primary and secondary HTN in some studies, DBP elevation -> more predictive of secondary HTN and systolic HTN -> more predictive of primary HTN.

Key Action Statement 11

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, and/or do not have history or physical examination findings (Table 14) suggestive of a secondary cause of HTN (grade C, moderate recommendation).

Secondary Causes: Renal and/or Renovascular

- Renal disease and renovascular disease are among the most common secondary causes of HTN in children and is more common in younger 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%.
- Consider renal/renovascular disease in hypertensive pediatric patients, **particularly in those <6 years of age.**

Secondary Causes: Cardiac, Including Aortic Coarctation

- Usually associated with HTN and right arm BP that is 20 mmHg (or more) greater than the lower extremity BP
- Patients with coarctation can remain hypertensive or develop HTN even after early and successful repair (with increase risk as time passes), with reported prevalence varying from 17% to 77%.
- HTN can be a manifestation of recoarctation.
- ABPM is gold standard of dx in this population.

Other secondary Causes:

- Endocrine HTN: Rare cause of secondary HTN in kids (prevalence ranging from 0.05% to 6%)
- Environmental Exposures (Lead, Mercury)
- Neurofibromatosis
- Medications: OCPs, stimulants, illicit drugs
- Monogenetic Forms: familial hyperaldosteronism type I (FH-I), Liddle syndrome, mineralocorticoid receptor activating mutation, and congenital adrenal hyperplasia, etc.

Diagnostic Evaluation

- History: Perinatal history, PMH, *nutritional history, *activity history, and *psychosocial history

**Areas of potential behavioral modifications*

- Physical Exam

Nutritional Hx:

- High sodium, total fat, saturated fat, fast food, sugary beverages intake
- Infrequent consumption of fruits, vegetables, and low-fat dairy products

Psychosocial History

- Stress: WCH?
- Depression and anxiety
- Bullying
- Body perceptions
- Starting at 11 years of age, the psychosocial history should include questions about smoking, alcohol, and other drug use.

Family Hx

- Quick and easy way to risk-stratify pediatric patients with an increased risk for HTN.
- Remember to update it as time passes!

Physical Exam:

- May provide clues to potential secondary causes of HTN
- Assess possible hypertensive end organ damage
- Height, weight, calculated BMI, and percentiles for age
- Poor growth may indicate an underlying chronic illness.
- BP is 10 to 20 mmHg higher in the legs than the arms. If the leg BP is lower than the arm BP, or if femoral pulses are weak or absent, coarctation of the aorta may be present.

Key Action Statement 13

In children and adolescents being evaluated for high BP, the provider should obtain a perinatal history, appropriate nutritional history, physical activity history, psychosocial history, and family history and perform a physical examination to identify findings suggestive of secondary causes of HTN (grade B, strong recommendation).

Diagnostic Evaluation: Labs

- UA
- BMP

Key Action Statement 14

Clinicians should not perform electrocardiography in hypertensive children and adolescents being evaluated for LVH (grade B, strong recommendation).

**Electrocardiography has high specificity but poor sensitivity for identifying children and adolescents with LVH.*

Imaging Evaluation: Echocardiography

- Multiple variables: LV ejection fraction, mass, relative wall thickness, and LV mass index (heart size in relation to body size)
- The costs and benefits of incorporation of echocardiography into HTN care has not been assessed, and further research is required to determine best way to measure LV mass.
- LVH improves with HTN treatment

Key Action Statement 15

- **It is recommended that echocardiography be performed to assess for cardiac target organ damage (LV mass, geometry, and function) at the time of consideration of pharmacologic treatment of HTN.**
- LVH should be defined as LV mass $>51 \text{ g/m}^2.7$ (boys and girls) for children and adolescents older than 8 years and defined by LV mass $>115 \text{ g/BSA}$ for boys and LV mass $>95 \text{ g/BSA}$ for girls;
- **Repeat echocardiography may be performed to monitor improvement or progression of target organ damage at 6- to 12-month intervals.** Indications to repeat echocardiography include persistent HTN despite treatment, concentric LV hypertrophy, or reduced LV ejection fraction; and
- In patients without LV target organ injury at initial echocardiographic assessment, repeat echocardiography at yearly intervals may be considered in those with stage 2 HTN, secondary HTN, or chronic stage 1 HTN incompletely treated (noncompliance or drug resistance) to assess for the development of worsening LV target organ injury (grade C, moderate recommendation).

Imaging for Renovascular Disease

- Consider 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.
- Limitations: patient cooperation, the technician's experience, the age of the child, and the child's BMI.

Key Action Statement 16

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 and who will cooperate with the procedure (grade C, moderate recommendation).

Dx Testing: Microalbuminuria

- MA can be from HTN damage or a nonspecific finding in children that can occur in the absence of HTN; (obesity, insulin resistance, diabetes, dyslipidemia, recent vigorous physical activity.)
- Small study shows improvement in LVH and LVMI with reduction of MA in HTN children without CKD.

Key Action Statement 18

Routine testing for MA is not recommended for children and adolescents with primary HTN (grade C, moderate recommendation).

Treatment Goals

- Achieve a BP level that reduces the risk for target organ damage in childhood AND reduces the risk for HTN and related CVD in adulthood
- Goal BP <90th percentile or <130/80 mm Hg, whichever is lower (previously <95th%)
- Lifestyle modifications
- Pharmacologic therapy

Key Action Statement 19

In children and adolescents diagnosed with HTN, the treatment goal with nonpharmacologic and pharmacologic therapy should be a reduction in SBP and DBP to <90th percentile and <130/80 mmHg in adolescents ≥ 13 years old (grade C, moderate recommendation).

Lifestyle Modifications: Diet

- Dietary Approaches to Stop Hypertension (DASH) = well studied
- High in fruits, vegetables, low-fat milk products, whole grains, fish, poultry, nuts, lean red meats
- Limited sugar and sweets
- Low sodium intake(<2300 mg/day)
- Plant-based diet and low-fat dairy product diets also associated with lower BP in children
- Can be more expensive... :(

*Correlations between dietary sodium and BP in childhood and elevated BP and HTN, particularly in people who are overweight or obese

TABLE 16 DASH Diet Recommendations

Food	Servings per Day
Fruits and vegetables	4–5
Low-fat milk products	≥ 2
Whole grains	6
Fish, poultry, and lean red meats	≤ 2
Legumes and nuts	1
Oils and fats	2–3
Added sugar and sweets (including sweetened beverages)	≤ 1
Dietary sodium	<2300 mg per d

Adapted from Berner TL, Grandell JL, Bell RA, Meyer Davis EJ, Deheles D, Lissa AD. Change in DASH diet score and

Lifestyle Modifications:

Physical Activity

- All types of exercise seem to provide BP benefit (aerobic, resistance, combined)
- Data is scant but seems to support correlation between increased exercise and lower BPs (analysis of 12 randomized controlled trials including 1266 subjects found reductions of 1% and 3% for resting SBP and DBP, respectively)
- Combination of diet and exercise show benefit on SBP
- Goal: moderate to vigorous physical activity at least 3 to 5 days per week, 30-60 mins/session

Key Action Statement 20

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 (grade C, weak recommendation).

Lifestyle Modifications: Weight Loss

- Intensive weight-loss therapy (regular patient and/or family contact and at least 1 hour of moderate to vigorous physical activity on a daily basis) should be offered to children and adolescents with obesity and HTN in addition to the standard lifestyle approaches

Lifestyle Modifications: Stress Reduction

- More data needed
- Breathing-awareness meditation shown to help lower SBP in normotensive and elevated BP adolescents in one study at University of Massachusetts
- Transcendental meditation showed no significant BP effect but showed decrease in LVM in adolescents with elevated BP
- Yoga may be helpful

Pharmacologic Treatment

- Children who
 - remain hypertensive despite a trial of lifestyle modifications
 - symptomatic HTN
 - stage 2 HTN without a clearly modifiable factor (obesity)
 - any stage of HTN associated with CKD or DM therapy

Pharmacologic Treatment continued

- What and How?
 - Low dose, single agent (ACE-I, ARB, CCB, thiazides)
 - Can titrate q 2-4 weeks using home BP measurements
 - Should see MD q 4-6 weeks until BP normalized
 - Add second agent if unable to control with monotherapy
 - Thiazide diuretic is often preferred second agent
- *Limited studies comparing anti-HTN agents in children, data shows efficacy of BP meds but no trials with CV end points as outcomes*

Pharmacologic Treatment continued

- Rx Choice:
 - ACE inhibitor
 - ARB
 - long-acting CCB
 - thiazide diuretic
- Can use other factors to choose agent:
 - CKD, proteinuria or DM
 - child-bearing age

Key Action Statement 21

In hypertensive children and adolescents who have failed lifestyle modifications (particularly those who have LV hypertrophy on echocardiography, symptomatic HTN, or stage 2 HTN without a clearly modifiable factor [eg, obesity]), clinicians should initiate pharmacologic treatment with an ACE inhibitor, ARB, long-acting calcium channel blocker, or thiazide diuretic (grade B, moderate recommendation)

Treatment Follow up and Monitoring

- After initiating anti-HTN Rx, pt should be seen every 4–6 weeks for dose adjustments and/or addition of a second or third agent until goal BP has been achieved
- Once goal BP achieved, should see pt q 3-4 months
- If treating with lifestyle changes alone, monitor q 3-6 mo to allow more time for lifestyle modifications effect

Follow Up:

- Assess therapy adherence
- Monitor medication side effects (labs if needed)
- Assess adherence to lifestyle modifications
- Known hypertensive target organ damage (such as LVH) should be reassessed as per reviewed recommendations
- ABPM may be useful in assessing Rx efficacy especially if home/clinic BPs do not show desired BP response to treatment

Comorbidities

- **Dyslipidemia:** screen and treat
- **DM:** type 2 > type 1
- **OSAS:** screen children with si/sx (eg, daytime fatigue, snoring, hyperactivity, etc.) for elevated BP regardless of treatment status, consider ABPM
- **Cognitive impairment:** Hypertensive children score lower on tests of neurocognition and on parental reports of executive function compared with normotensive controls, increased prevalence of learning disabilities in children with primary HTN compared with normotensive controls.

Special Considerations: HTN and Sports

- 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.
- Athletes identified as hypertensive (eg, during preparticipation sports screening) should undergo appropriate evaluation. For athletes with more severe HTN (stage 2 or greater), treatment should be initiated before sports participation.

Summary

- Peds = more secondary HTN than adults but majority of HTN in peds *in the US* = primary
- Auscultation is gold standard of HTN dx
- 3 strikes you're out
- If it looks like a chicken and smells like a chicken...
- Do a good Hx and PE in all pts with elevated BP
- All peds pts with confirmed Elevated BP/HTN should get UA, BMP, lipid panel +/- A₁C, LFTs
- Treat to SBP and DBP <90th percentile and <130/80 mmHg in adolescents ≥ 13 years old
- Prevention is Priceless

References

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Thank you 😊

Questions?