

# High Blood Pressure in Pediatrics

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# Objectives

- Review epidemiology of pediatric hypertensive disorders
- Compare screening guidelines for HTN in children and adolescents
- Define elevated blood pressure, stage 1, and stage 2 hypertension in children and adolescents
- Discuss work-up and management of elevated blood pressure and hypertension in the pediatric population

# Case

11yo M with h/o obesity, chronic abdominal pain, fatty liver, and “prehypertension” is BIB mom for his WCC. No acute complaints.

Vitals: BP 132/80 | Pulse 96 | Temp 98 °F (36.7 °C) (Oral) | Ht 4' 9" (1.448 m) | Wt 125 lb (56.7 kg) | BMI 27.04 kg/m<sup>2</sup> (98th%)

PE: +acanthosis nigricans

LABS last month for abdominal pain:

AST 60, ALT 118, UA negative, CBC WNL, ESR and CRP wnl

# Prevalence of High BP in Peds

- Increasing prevalence of high blood pressure in children and adolescents (both elevated BP and HTN)
- **Boys** (15-19%) > girls (7-12%)
- **Hispanics and non-Hispanic African Americans** > non-Hispanic white children
- **Adolescents** > younger children

*\*Based on National Health and Nutrition Examination Survey (NHANES), based on single BP readings*

# Prevalence of High BP in Peds continued...

- ***In a clinical setting and with repeated BP measurements***, the prevalence of confirmed HTN is lower than based on NHANES data 2/2
  - 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 ( $\geq 85^{\text{th}}$  -  $<95^{\text{th}}$  percentile BMI) and obese ( $\geq 95^{\text{th}}$  percentile BMI)

1. Flynn, J.T., et.al. *SUBCOMMITTEE ON SCREENING AND MANAGEMENT OF HIGH BLOOD PRESSURE IN CHILDREN. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics Sep 2017, 140 (3) e20171904; DOI: 10.1542/peds.2017-1904*

# Prevalence of High BP in Peds continued...

- Primary HTN:
  - more common in older children (>6yo)
  - associated with elevated BMI, +Family Hx of HTN
- Secondary HTN:
  - more common in younger children (<6yo)
  - most commonly caused by renal disease, also genetic disorders, endocrine disorders, or cardiovascular abnormalities.
- SBP elevation -> more predictive of primary HTN.
- DBP elevation -> more predictive of secondary HTN

# Why Should We Care?

- Higher BP in childhood -> higher risk of HTN and metabolic syndrome in adulthood
- Normal BP in childhood is associated with a lack of HTN in mid-adulthood.
- Hypertensive children score lower on neurocognitive tests 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
- Elevated BP in childhood increases the risk for adult HTN and metabolic syndrome.
- Young patients with HTN are likely to experience accelerated vascular aging (increased LVM, carotid intima-media thickness) -> **CVD begins in childhood!**

# 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 waste 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 of  $\geq 10\%$  in mean BP levels from day to night (non-dippers = increased CV risk as adults)
- 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)

- Prevalence of high BP between 3.6% and 14%
- Includes:
  - primary snoring
  - sleep fragmentation
  - obstructive sleep apnea syndrome (OSAS)
- Children who sleep  $\leq 7$  hours/night are at increased risk for HTN
- 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?

# What are the current screening recommendations?

## USPSTF (2020)

Current evidence is insufficient to assess the balance of benefits and harms of screening for high blood pressure in children and adolescents ages 3-18yo. (I statement)

# What are the current screening recommendations?

## AAP (2017)\*

- **BP should be measured annually in children and adolescents  $\geq 3$  years of age (grade C, moderate recommendation).**
- BP should be checked in all children and adolescents  $\geq 3$  years of age at every health care encounter if they have **obesity, are taking medications known to increase BP (stimulants, TCAs, COCs), have renal disease, a history of aortic arch obstruction or coarctation, or diabetes** (grade C, moderate recommendation).
- Children younger than 3 yo should have BP measurements taken at well-child care visits if they are at increased risk for developing HTN (h/o prematurity, solid organ transplant, etc.)

\*endorsed by the American Heart Association

# HTN Definitions (1-18yo)

- Normative distribution of BP in healthy, normal weight children
- Based on auscultation (vs oscillometric or ABPM readings)
- Must consider pt's
  - age
  - height
  - sex
- Classifications for  $\geq 13$ yo aligns with AHA and ACC adult terminology and guidelines

# Current Definitions of Pediatric BP Categories

**TABLE 3** Updated Definitions of BP Categories and Stages

For Children Aged 1–<13 y	For Children Aged $\geq 13$ y
Normal BP: <90th percentile	Normal BP: <120/<80 mm Hg
Elevated BP: $\geq 90$ th 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: $\geq 95$ th 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: $\geq 95$ th percentile + 12 mm Hg, or $\geq 140/90$ mm Hg (whichever is lower)	Stage 2 HTN: $\geq 140/90$ mm Hg



# Children/Adolescent BP Tables

- Based on auscultatory measurements obtained from ~50,000 *normal weight* children and adolescents
- No data on cut off for BP in childhood -> adverse CV outcomes in adulthood
- 4 categories:
  - normal (50th percentile)
  - elevated BP (>90th percentile)
  - stage 1 HTN ( $\geq$ 95th percentile)
  - stage 2 HTN ( $\geq$ 95th percentile + 12 mmHg).
- Heights in centimeters and inches provided (not just percentiles)
- Includes 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	59	60	61	61
	95th + 12 mm Hg	116	117	118	119	120	121	122	69	70	71	71	72	73	74

# 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

# Back to our Case

How do you classify this 11yo M's initial BP reading?

Vitals: BP 132/80 | Pulse 96 | Temp 98 °F (36.7 °C) (Oral) | Ht 4' 9" (1.448 m) | Wt 125 lb (56.7 kg) | BMI 27.04 kg/m<sup>2</sup> (98th%)

11	Height (in)	53	54	55.7	57.6	59.6	61.3	62.4	53	54	55.7	57.6	59.6	61.3	62.4
	Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
	50th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
	90th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
	95th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
	95th + 12 mm Hg	126	126	128	130	132	135	136	89	90	90	90	90	90	90

# Diagnosing Elevated BP requires 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
- Child should be
  - sitting in quiet room for 3-5 minutes
  - back supported
  - feet flat
  - legs uncrossed
  - with appropriate sized cuff

# 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 BP table
- If oscillometric avg  $\geq$ 90th percentile -> take 2 auscultatory measurements and average them, categorize based on BP table

# Back to our Case

- You manually check your patient's BP, and the avg of 2 readings = 127/76
- How do you classify this 11yo M's current BP?

Ht 4' 9" (1.448 m)

11	Height (in)	53	54	55.7	57.6	59.6	61.3	62.4	53	54	55.7	57.6	59.6	61.3	62.4
	Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
	50th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
	90th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
	95th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
	95th + 12 mm Hg	126	126	128	130	132	135	136	89	90	90	90	90	90	90

# Initial Management: Normal BP (<90th%)

- Nothing further indicated
- Recheck BP at next WCC



# Initial Management:

Elevated BP ( $\geq 90$ th% or  $\geq 120/80$ )

- Recommend lifestyle interventions (ie, healthy diet, sleep, and physical activity)
- Consider nutrition and/or weight management referral
- **F/u in 6 months** for BP check by auscultation

# 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
  - **6 mo BP check** by auscultation
- If BP remains elevated after 12 months (i.e., after 3 auscultatory measurements):
  - Ambulatory Blood Pressure Monitoring (if available, may require referral to specialist)
  - diagnostic evaluation
  - 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 ( $\geq 95$ th% or $\geq 130/80$ )

- If pt asx:
  - lifestyle counseling
  - **BP check in 1 to 2 weeks** by auscultation
- If pt sx: send to ED

# Back to our Case

- Patient returns in 3 months instead of 1-2 weeks.
- Has seen a nutritionist 3 times, is running track at school but has gained 4 lbs since last visit
- You manually check your patient's BP: avg of 2 readings = 120/78
- How do you classify this 11yo M's current BP?

Ht 4' 9" (1.448 m)

11	Height (in)	53	54	55.7	57.6	59.6	61.3	62.4	53	54	55.7	57.6	59.6	61.3	62.4
	Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
	50th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
	90th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
	95th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
	95th + 12 mm Hg	126	126	128	130	132	135	136	89	90	90	90	90	90	90

# F/u Management: Stage 1 HTN

- If the BP reading still stage 1 HTN:
  - BUE and one LE BP checked
  - nutrition and/or weight management referral
  - **BP check in 3 months** by auscultation
- If BP continues to be at the stage 1 HTN level after 3 visits:
  - ABPM (if available)
  - diagnostic evaluation
  - **initiate treatment**
  - consider subspecialty referral

# Back to our Case

- BUE and 1 LE BP readings not c/w coarctation, remain in stage 1 HTN range
- You refer pt to child weight management program, encourage continued f/u with nutrition and regular exercise
- You check labs early:
  - A<sub>1</sub>C 6.0
  - LDL 132, HDL 40, TG 177
  - AST 93, ALT 144
- Plan for f/u in 3 months: *Outcome TBD*

# Initial Management:

Stage 2 HTN ( $\geq 95^{\text{th}}\%$  + 12 mm Hg or  $\geq 140/90$ )

- If pt asx:
  - check BUE and one LE BP
  - lifestyle recommendations
  - **BP check within 1 week.**
- ***OR*** refer to subspecialty care within 1 week
  
- If pt sx or BP  $>30$  mm Hg above 95th% (or  $>180/120$  mm Hg in an adolescent): send to ED

# F/u Management: Stage 2 HTN

- If the BP reading is still c/w stage 2 HTN level:
  - diagnostic evaluation
  - ABPM
  - **initiate treatment**
- **OR** refer to subspecialty care within 1 week.
  
- If pt sx or BP  $>30$  mm Hg above 95th% (or  $>180/120$  mm Hg in an adolescent): send to 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 <sup>a</sup>	Diagnostic Evaluation <sup>b</sup>	Initiate Treatment <sup>c</sup>	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 <sup>d</sup>	Initial measurement	X	X	—	—	—	—
	Second measurement: repeat, refer to specialty care within 1 wk	X	—	X	X	X	X

X, recommended intervention; —, not applicable.

<sup>a</sup> ABPM is done to confirm HTN before initiating a diagnostic evaluation.

<sup>b</sup> See Table 15 for recommended studies.

<sup>c</sup> Treatment may be initiated by a primary care provider or subspecialist.

<sup>d</sup> 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.

# Diagnostic evaluation for elevated BP/HTN

- All children:
  - UA
  - BMP
  - lipids
  - renal US (if <6yo or abnormal UA/GFR)
- Obese children, add:
  - A<sub>1</sub>C
  - LFTs
- Optional, based on Hx/PE/initial results:
  - Fasting glc
  - TSH
  - Drug screen
  - Sleep study
  - CBC

# Do ALL Children need a full work up?

- Children and adolescents  $\geq 6$  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 suggestive of a secondary cause of HTN (grade C, moderate 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
- 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
- Helps identify Masked HTN (normal office BP but elevated BP on ABPM) and White Coat HTN (WCH)

*\*May require specialist referral*

# 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*

# Don't forget your Hx and PE!

- **Perinatal Hx:** low BW, preterm?
- **Family Hx:** HTN?
- **Nutritional Hx:** high sodium, total fat, saturated fat, fast food, sugary beverages intake? Infrequent consumption of fruits, vegetables, and low-fat dairy products?
- **Psychosocial Hx:**
  - 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
- **PE:** signs of secondary causes?

# Imaging: EKGs - pass

- Clinicians should not perform electrocardiography in hypertensive children and adolescents being evaluated for LVH (grade B, strong recommendation).
- EKGs have high specificity but poor sensitivity for identifying children and adolescents with LVH.



# Imaging: Echocardiography - yes, please!

- Multiple variables: LV ejection fraction, mass, relative wall thickness, and LV mass index (heart size in relation to body size)
- LVH improves with HTN treatment
- Further research needed
- For now, order at when considering treatment initiation, consider repeat in 6-12 months

# Imaging for Renovascular Disease? Perhaps...

- Doppler renal ultrasonography may be used as a noninvasive screening study for the evaluation of possible RAS in normal-weight children and adolescents  $\geq 8$  years of age who are suspected of having renovascular HTN and who will cooperate with the procedure (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
- Lifestyle modifications
- Pharmacologic therapy

# 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

# Lifestyle Modifications:

## Physical Activity

- All types of exercise provide BP benefit (aerobic, resistance, combined)
- Goal: moderate to vigorous physical activity at least 3 to 5 days per week, 30-60 mins/session

# Lifestyle Modifications: Weight Loss

- If available, 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

# 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

# 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  $\geq 13$  years old
- **Prevention is Priceless**

# References

1. Flynn, J.T., et.al. SUBCOMMITTEE ON SCREENING AND MANAGEMENT OF HIGH BLOOD PRESSURE IN CHILDREN. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. *Pediatrics* Sep 2017, 140 (3) e20171904; DOI: 10.1542/peds.2017-1904
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Thank you 😊

Questions?