Pediatric Hypertension

Dima Turpin, MD, FAAP, FACC

Director, Preventive Cardiology and Lipid Clinic

Director, Nemours Lakeland Cardiology Services

Nemours Children's Hospital Orlando

Pediatric Hypertension

* A study by the CDC demonstrated that 1 in 25 youth ages 12-19 have hypertension.

* 1 in 10 have elevated blood pressure.

Joseph T. Flynn, MD, MS, FAAP,a David C. Kaelber, MD, PhD, MPH, FAAP, FACP, FACMI,b Carissa M. Baker-Smith, MD, MS, MPH, FAAP, FAHA,c Douglas Blowey, MD,d Aaron E. Carroll, MD, MS, FAAP,e Stephen R. Daniels, MD, PhD, FAAP,f Sarah D. de Ferranti, MD, MPH, FAAP,g Janis M. Dionne, MD, FRCPC,h Bonita Falkner, MD,i Susan K. Flinn, MA,j Samuel S. Gidding, MD,k Celeste Goodwin,l Michael G. Leu, MD, MS, MHS, FAAP,m Makia E. Powers, MD, MPH, FAAP,n Corinna Rea, MD, MPH, FAAP,o Joshua Samuels, MD, MPH, FAAP,p Madeline Simasek, MD, MSCP, FAAP,q Vidhu V. Thaker, MD, FAAP,r Elaine M. Urbina, MD, MS, FAAP,s SUBCOMMITTEE ON SCREENING AND MANAGEMENT OF HIGH BLOOD PRESSURE IN CHILDREN Pediatrics August 2017 From the American Academy of Pediatrics

NEMOURS CHILDREN'S HEALTH

-Elevated blood pressure in childhood has been linked to hypertension in adulthood and subclinical target organ damage.

-Epidemiological studies have demonstrated the association between childhood hypertension and atherosclerosis and premature mortality.

- Urbina EM, Mendizábal B, Becker RC, Daniels SR, Falkner BE, Hamdani G, Hanevold C, Hooper SR, Ingelfinger JR, Lanade M, et al. Association of blood pressure level with left ventricular mass in adolescents. *Hypertension*. 2019;74:590–596. doi: 10.1161/HYPERTENSIONAHA.119.13027 Crossref. PubMed.
- Sundström J, Neovius M, Tynelius P, Rasmussen F. Association of blood pressure in late adolescence with subsequent mortality: cohort study of Swedish male conscripts. *BMJ*. 2011;342:d643. doi: 10.1136/bmj.d643 Crossref. PubMed.

NEMOURS CHILDREN'S HEALTH

Extensive literature relates elevated BP to adverse changes in carotid intima-media thickness (cIMT), pulse wave velocity, left ventricular hypertrophy (LVH), and neurocognition.

Individuals with persistently elevated BP during childhood and adulthood have a greater relative risk for higher cIMT and pulse wave velocity as adults than those with normal BP

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CHILDREN'S HEALTH

Both LVH and changes in left ventricular systolic and diastolic function occur in children at BP levels below current thresholds for the diagnosis of hypertension.

longitudinal studies have shown that the long-term burden of elevated systolic BP (SBP) during adolescence is associated with adult LVH.

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AHA SCIENTIFIC STATEMENT

Ambulatory Blood Pressure Monitoring in Children and Adolescents: 2022 Update: A Scientific Statement From the American Heart Association

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NEMOURS CHILDREN'S HEALTH

Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents

- Joseph T. Flynn, MD, MS, FAAP,a David C. Kaelber, MD, PhD, MPH, FAAP, FACP, FACMI,b Carissa M. Baker-Smith, MD, MS, MPH, FAAP, FAHA,c Douglas Blowey, MD,d Aaron E. Carroll, MD, MS, FAAP,e Stephen R. Daniels, MD, PhD, FAAP,f Sarah D. de Ferranti, MD, MPH, FAAP,g Janis M. Dionne, MD, FRCPC,h Bonita Falkner, MD,i Susan K. Flinn, MA,j Samuel S. Gidding, MD,k Celeste Goodwin,l Michael G. Leu, MD, MS, MHS, FAAP,m Makia E. Powers, MD, MPH, FAAP,n Corinna Rea, MD, MPH, FAAP,o Joshua Samuels, MD, MPH, FAAP,p Madeline Simasek, MD, MSCP, FAAP,q Vidhu V. Thaker, MD, FAAP,r Elaine M. Urbina, MD, MS, FAAP,s SUBCOMMITTEE ON SCREENING AND MANAGEMENT OF HIGH BLOOD PRESSURE IN CHILDREN

- Pediatrics
- August 2017
- From the American Academy of Pediatrics
- Clinical Practice Guideline

National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics. 2004;114(2, suppl 4th Report):555–576

Obesity

-Overweight and obesity HTN prevalence: 3.8-24.8%

Rates increase with increasing adiposity, abdominal circumference.

-Lack of circadian BP variability in up to 50% of obese children.

-Related to future HTN

-Elevated BMI as early as infancy: future HTN.

-Associated cardiometabolic risk factors: dyslipidemia, abnormal glucose metabolism.

Obesity

Strong Heart Study: American Indian adolescents with multiple cardio metabolic risk factors had a higher prevalence of:

- LVH (43.2% vs 11.7%),

- left atrial dilation (63.1% vs 21.9%; P < .001)

- reduced LV systolic and diastolic function

Compared with those without multiple cardiometabolic risk factors.

Obesity was a stronger determinant of cardiac abnormalities than HTN (odds ratio 4.17 vs 1.03).

Sleep Disordered Breathing SDB

(1) primary snoring

(2) sleep fragmentation

(3) obstructive sleep apnea syndrome (OSAS)

SDB and HTN

- Less than 7 hours of sleep per night associated with HTN in children.
- Prevalence of 3.6-14%.
- Positive association with severity of OSAS

Chronic Kidney Disease CKD

50% of children with CKD have HTN.

48-79% of children with end stage KD have HTN, high percentage of uncontrolled HTN.

20% of pediatric HTN is secondary to CKD.

History of Prematurity

Preterm birth and low birth weight— Risk factor for HTN and other CVD in adults

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

preterm birth may result in abnormal circadian BP patterns in childhood.#

* Mhanna MJ, Iqbal AM, Kaelber DC. Weight gain and hypertension at three years of age and older in extremely low birth weight infants. J Neonatal Perinatal Med. 2015;8(4):363–369

Bayrakci US, Schaefer F, Duzova A, Yigit S, Bakkaloglu A. Abnormal circadian blood pressure regulation in children born preterm. J Pediatr. 2007;151(4):399–403

HTN in Childhood

- Elevated BP in childhood-- ↑risk for adult HTN and metabolic syndrome.
- Youth with higher BP levels in childhood --- more likely to have persistent HTN as adults.
- Young patients with HTN ---- accelerated vascular aging.
- Both autopsy and imaging studies have demonstrated BP-related CV damage in youth.
- Measured markers (LVH, cIMT, PWV) predict CV events in adults.

Updated Definitions of BP Categories/ Stages

1–<13 y	≥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

Definition scheme

This was chosen, especially in the >13 year old population to align with the adult population guidelines.

To facilitate the management of older adolescents.

Definition of HTN

-We maintain a **statistical definition** for childhood hypertension:

-Lack of outcome data.

-Lack of data to identify a specific level of BP in childhood that leads to adverse CV outcomes in adulthood.

-The **staging criteria** have been revised for ease of implementation.

-Pre-hypertension has been replaced by the term "**elevated blood pressure**" to be consistent with the AHA and the ACC guideline.

BP Tables

-Are based on **normal weight children** (Same population data but do not include children with obesity and overweight). Values are ***lower*** than previous tables.

-**Auscultatory** measurements on 50,000 children

-Categorized as:

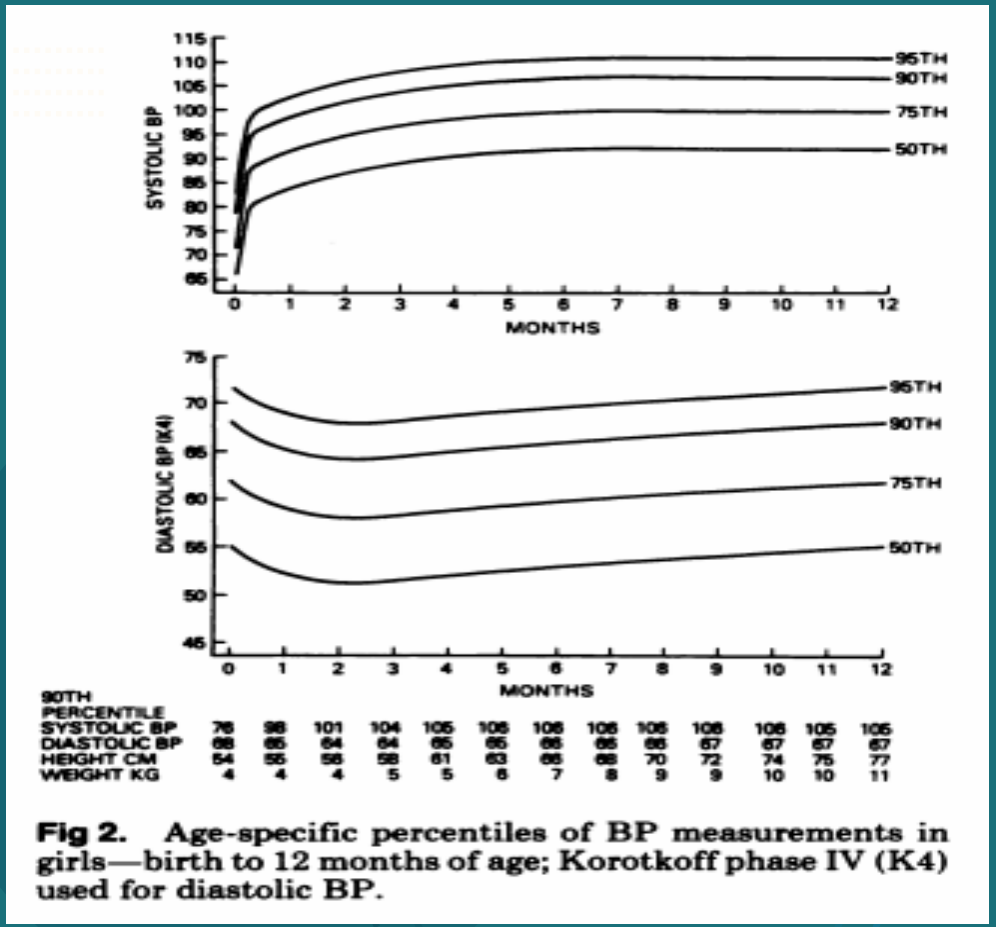
- Normal: 50th percentile
- Elevated BP: >90th percentile
- Stage 1 HTN: ≥95th percentile
- Stage 2 HTN: ≥95th percentile + 12 mmHg

-**Actual heights** in centimeters and inches are provided.

Simplified BP Table

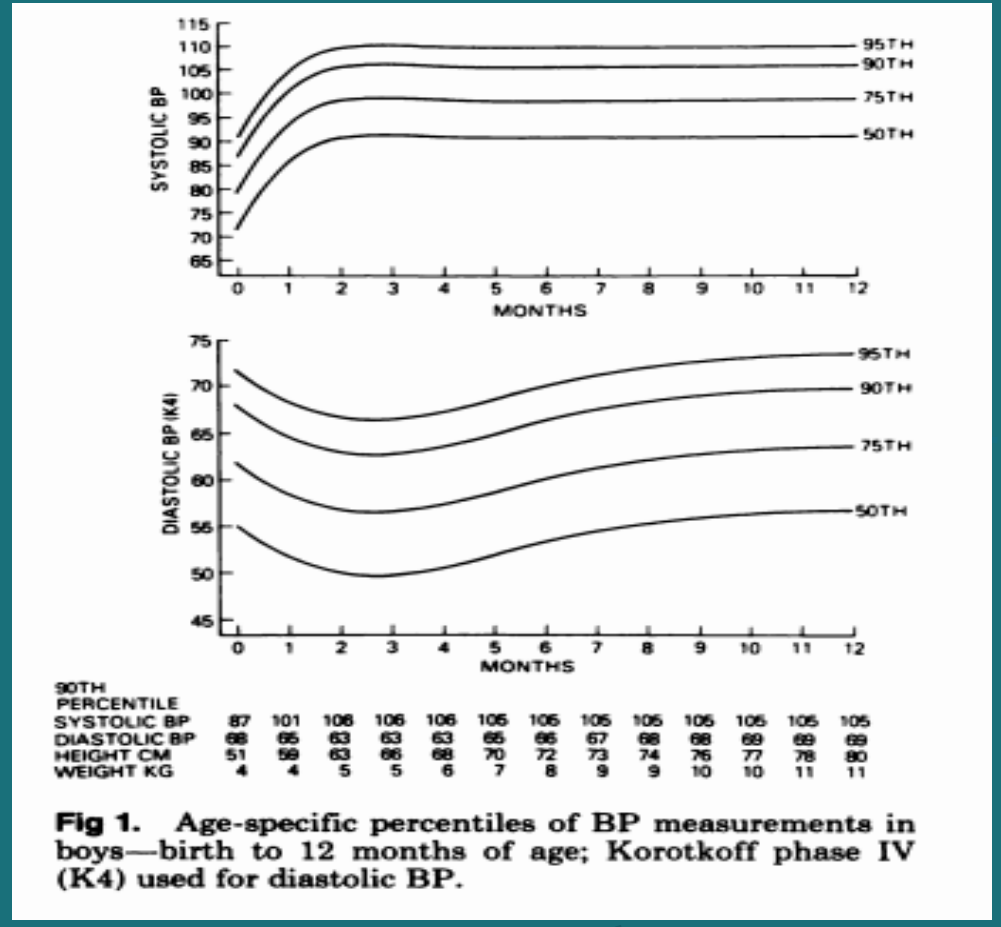
Boys	BP(mmHg)	
Age (y)	Systolic	Diastolic
• 1	98	52
• 2	100	55
• 3	101	58
• 4	102	60
• 5	103	63
• 6	105	66
• 7	106	68
• 8	107	69
• 9	107	70
• 10	108	72
• 11	110	74
• 12	113	75
• >=13	120	80

Girls	BP (mmHg)	
Age (y)	Systolic	Diastolic
*1	98	54
• 2	101	58
• 3	102	60
• 4	103	62
• 5	104	64
• 6	105	67
• 7	106	68
• 8	107	69
• 9	108	71
• 10	109	72
• 11	111	74
• 12	114	75
• >=13	120	80



90TH PERCENTILE														
SYSTOLIC BP	76	98	101	104	105	106	106	106	106	106	106	105	105
DIASTOLIC BP	68	65	64	64	65	65	66	66	66	67	67	67	67
HEIGHT CM	54	55	56	58	61	63	66	68	70	72	74	75	77
WEIGHT KG	4	4	4	5	5	6	7	8	9	9	10	10	11

Fig 2. Age-specific percentiles of BP measurements in girls—birth to 12 months of age; Korotkoff phase IV (K4) used for diastolic BP.



90TH PERCENTILE														
SYSTOLIC BP	87	101	106	106	106	105	106	105	105	105	105	105	105
DIASTOLIC BP	68	65	63	63	63	65	66	67	68	68	69	69	69
HEIGHT CM	51	59	63	66	68	70	72	73	74	76	77	78	80
WEIGHT KG	4	4	5	5	6	7	8	9	9	10	10	11	11

Fig 1. Age-specific percentiles of BP measurements in boys—birth to 12 months of age; Korotkoff phase IV (K4) used for diastolic BP.

Normative BP values in older infants up to 1 year

- Report of the second task force on blood pressure control in children–1987. Task force on blood pressure control in children. National Heart, Lung, and Blood Institute, Bethesda, Maryland. Pediatrics. 1987;79(1):1–25

- Dionne JM, Abitbol CL, Flynn JT. Hypertension in infancy: diagnosis, management and outcome [published correction appears in Pediatr Nephrol. 2012;27(1):159-60]. Pediatr Nephrol. 2012;27(1):17–32

Postconceptional age	50th percentile	95th percentile	99th percentile
44 Weeks			
SBP	88	105	110
DBP	50	68	73
MAP	**63**	**80**	**85**
42 Weeks			
SBP	85	98	102
DBP	50	65	70
MAP	**62**	**76**	**81**
40 Weeks			
SBP	80	95	100
DBP	50	65	70
MAP	**60**	**75**	**80**
38 Weeks			
SBP	77	92	97
DBP	50	65	70
MAP	**59**	**74**	**79**
36 Weeks			
SBP	72	87	92
DBP	50	65	70
MAP	**57**	**72**	**71**
34 Weeks			
SBP	70	85	90
DBP	40	55	60
MAP	**50**	**65**	**70**
32 Weeks			
SBP	68	83	88
DBP	40	55	60
MAP	**48**	**62**	**69**
30 Weeks			
SBP	65	80	85
DBP	40	55	60
MAP	**48**	**65**	**68**
28 Weeks			
SBP	60	75	80
DBP	38	50	54
MAP	**45**	**58**	**63**
26 Weeks			
SBP	55	72	77

tandardized protocol for blood pressure measurement in neonat

- Measured by oscillometric device
- 1.5 h after a feed or medical intervention
- Infant lying prone or supine
- Appropriately sized BP cuff
- Right upper arm
- After cuff placement, infant is left undisturbed for 15 min
- Infant asleep or in quiet awake state
- 3 successive BP readings at 2-min intervals

P, Blood pressure

- Dionne JM, Abitbol CL, Flynn JT. Hypertension in infancy: diagnosis, management and outcome [published correction appears in Pediatr Nephrol. 2012;27(1):159-60]. Pediatr Nephrol. 2012;27(1):17–32

EHR

- -Should be designed to flag abnormal values.
- -Should alert clinicians when BP measurement is missing at WCC.
- -Should provide decision support.

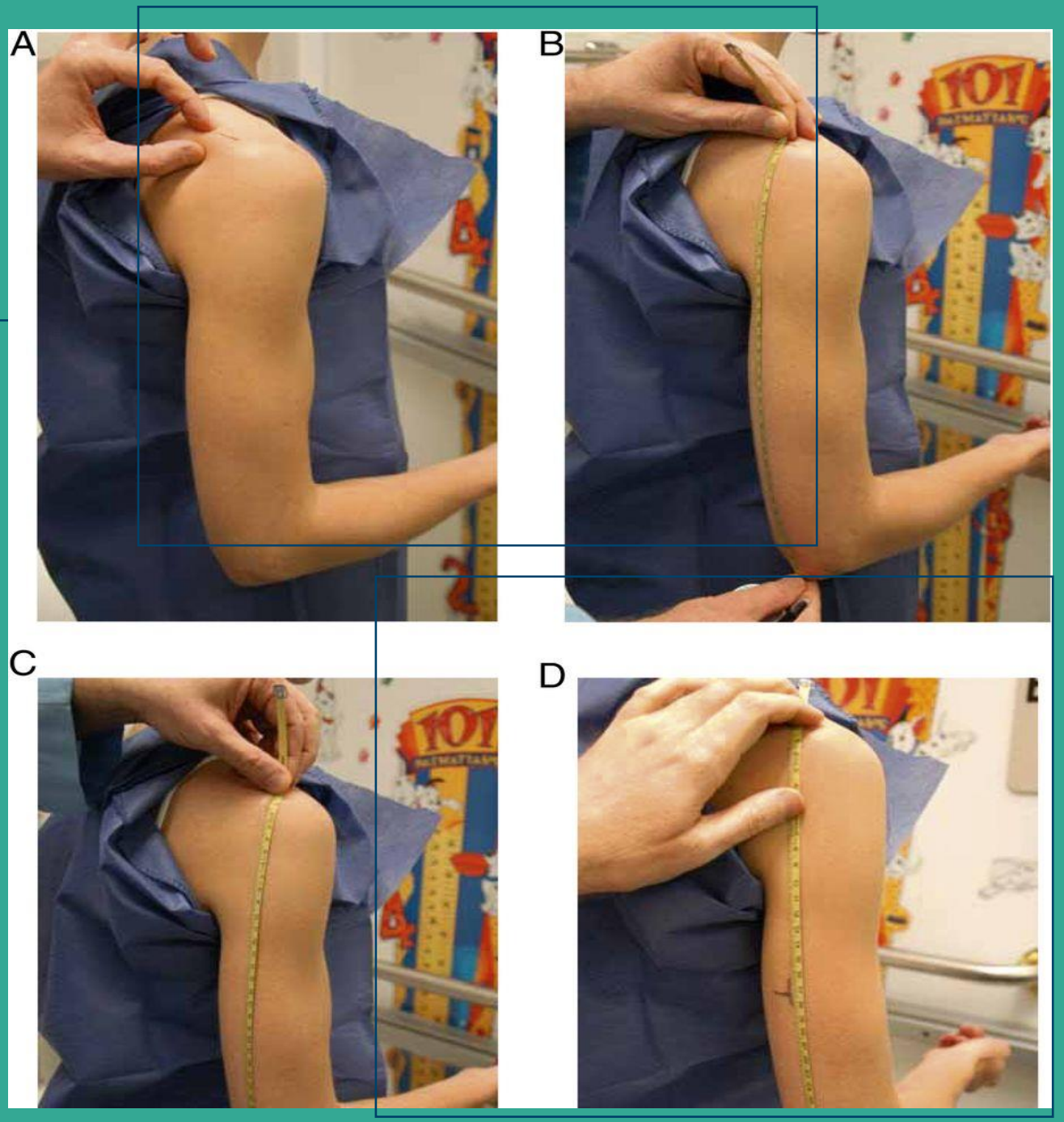
- **Proper BP cuff size.**

- A, Marking spine extending from acromion process.

- B, Correct tape placement for upper arm length.

- C, Incorrect tape placement for upper arm length.

- D, Marking upper arm length midpoint.



Neonates & Toddlers

-Hospital setting: intra-arterial, oscillometric.

-Outpatient: Oscillometric, Doppler, manual.

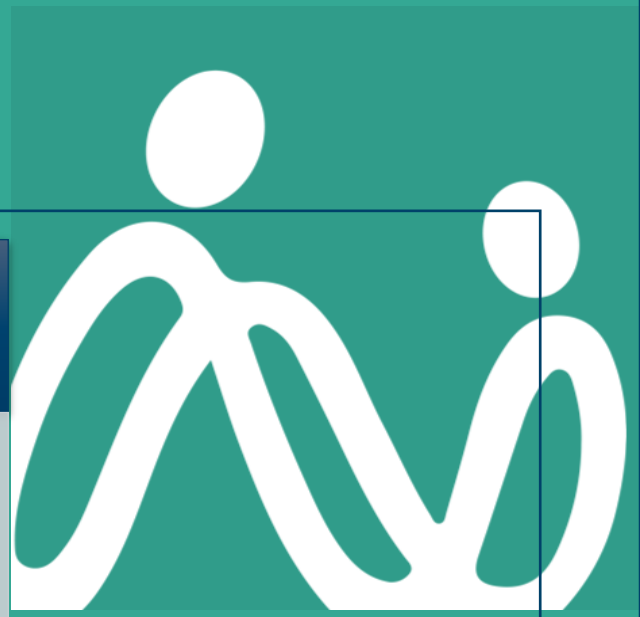
-Right upper arm while infant is supine.

-Cuff size rules DO apply.

-Need to have variety of cuff sizes available in office.

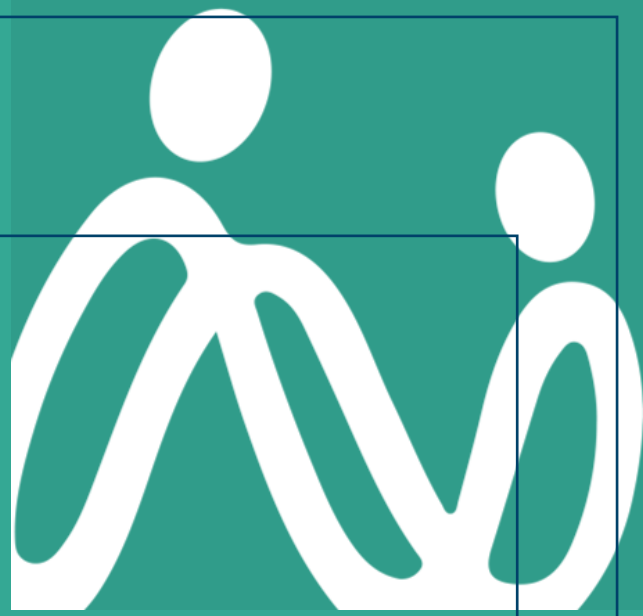
Frequency of BP Surveillance

Start	Measure	Measure
Start at age 3 years.	If otherwise healthy, only measure yearly.	Measure at every health encounter if: • Obese • Diabetic • Renal disease • Aortic arch obstruction • Medications known to cause HTN • Syndromes associated with HTN: Turner, Williams, NF.



Younger Than 3 Years

Oscillometric Devices



Inaccurately high readings for both SBP and DBP

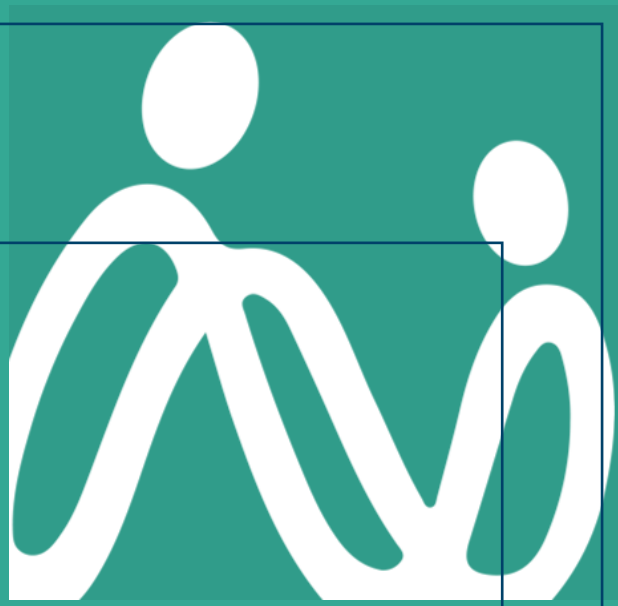
Great within-visit variation

May be used for screening

Confirmation of any suspected abnormal reading should always be done by auscultation.

Target organ damage from HTN is best predicted by auscultation.

Wrist BP Monitors



Limited data.

Not recommended in the diagnosis or treatment of HTN in children at this time.

Ambulatory BP Monitors

- -Routine application now recommended especially in high risk conditions.
- -More accurate than clinic measured BP
- -More predictive of future BP
- -Can assist in diagnosis of:
  - Secondary HTN
  - White coat HTN (WCH)
  - Masked HTN
  - Nocturnal HTN
- -LVH correlates more strongly with ABPM than casual BP.
- -More reproducible.

Ambulatory BP Monitoring

New data linking ambulatory blood pressure levels with the development of blood pressure–related target organ damage.

Sundström J, Neovius M, Tynelius P, Rasmussen F. Association of blood pressure in late adolescence with subsequent mortality: cohort study of Swedish male conscripts. *BMJ*. 2011;342:d643. doi: 10.1136/bmj.d643 Crossref. PubMed.

Urbina EM, Mendizábal B, Becker RC, Daniels SR, Falkner BE, Hamdani G, Hanevold C, Hooper SR, Ingelfinger JR, Lanade M, et al. Association of blood pressure level with left ventricular mass in adolescents. *Hypertension*. 2019;74:590–596. doi: 10.1161/HYPERTENSIONAHA.119.13027

AHA SCIENTIFIC STATEMENT

Ambulatory Blood Pressure Monitoring in Children and Adolescents: 2022 Update: A Scientific Statement From the American Heart Association

NEMOURS CHILDREN'S HEALTH

Masked HTN

-Normal office BP and abnormal ABPM.

-5.8% of children studied by ABPM. (CKD, CoA, Obesity).

-Significant risk of end organ damage.

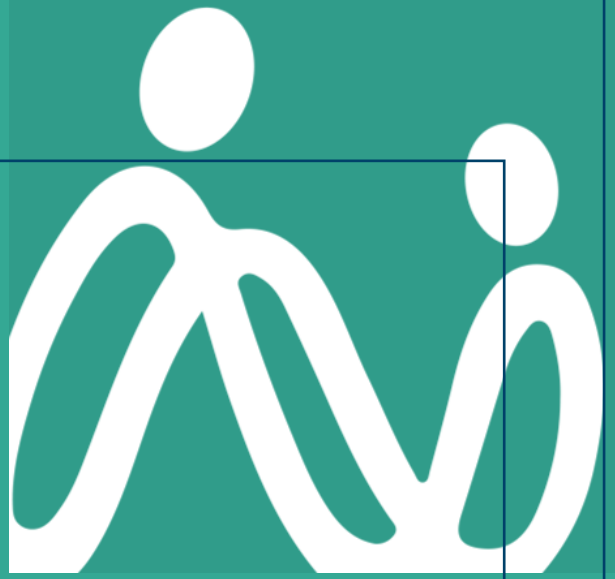
White Coat HTN, WCH

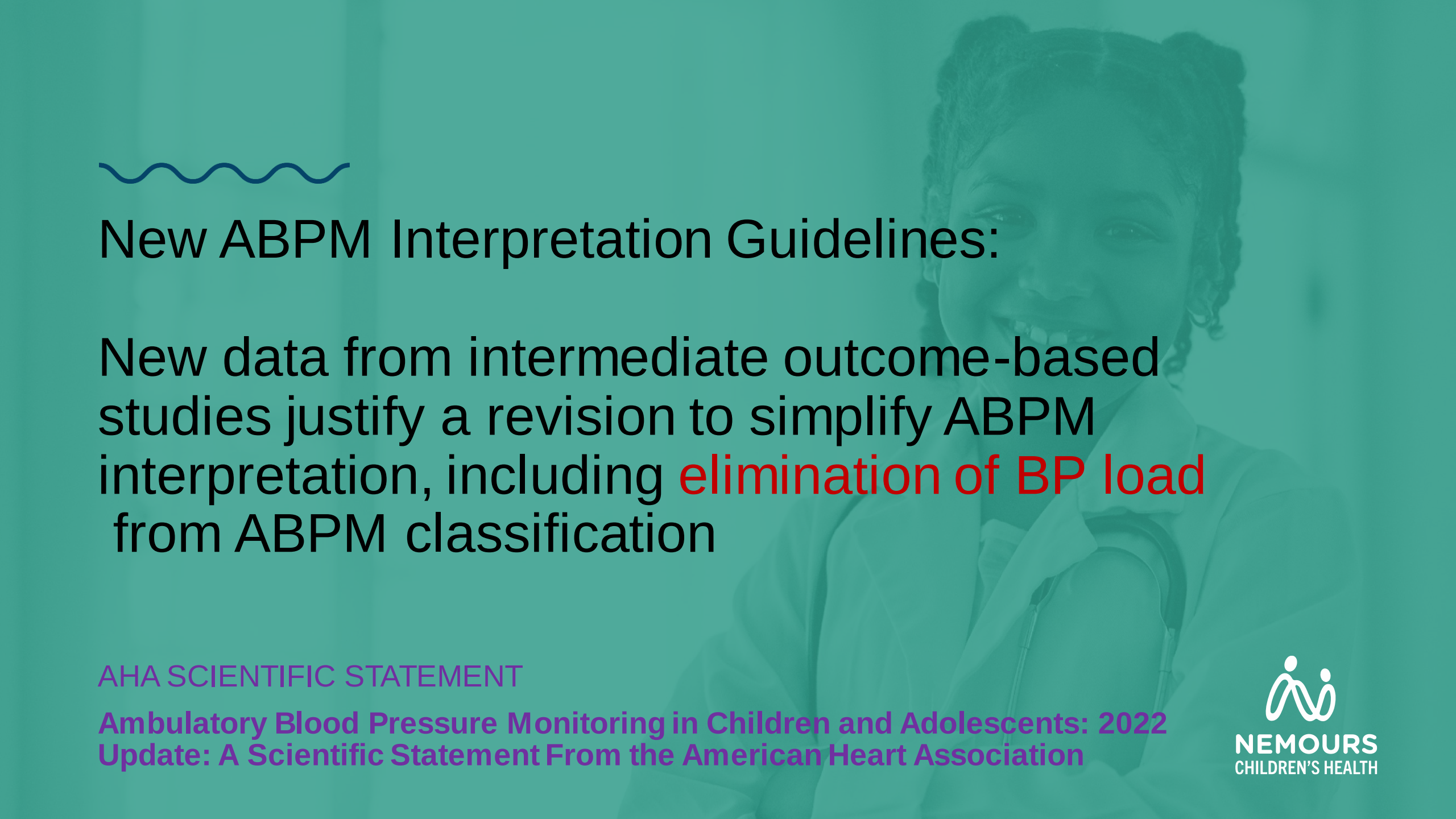
-BP >=95th percentile in office but <95th percentile outside office.

-ABPM: Mean SBP and DBP <95th percentile.

-Up to 50% of children thought to have HTN in office are said to have WCH

-Check BP at WCC and consider repeating ABMP in 1-2 years.





New ABPM Interpretation Guidelines:

New data from intermediate outcome-based studies justify a revision to simplify ABPM interpretation, including elimination of BP load from ABPM classification

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NEMOURS CHILDREN'S HEALTH

Revised Classification for Ambulatory Blood Pressure Studies in Pediatric Patients

Category	Clinic systolic or diastolic BP		Mean ambulatory systolic or diastolic BP	
	<13 y of age	≥13 y of age	<13 y of age	≥13 y of age
Normal BP	<95th percentile	<130/80	<95th percentile OR adolescent cut points*	<125/75 mm Hg 24-h AND <130/80 mm Hg wake AND <110/65 mm Hg sleep
WCH	≥95th percentile	≥130/80		
Masked hypertension	<95th percentile	<130/80	≥95th percentile OR adolescent cut points*	≥125/75 mm Hg 24-h OR ≥130/80 mm Hg wake OR ≥110/65 mm Hg sleep
Ambulatory hypertension	≥95th percentile	≥130/80		

ABPM for High Risk Conditions

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]

BP measurement in Obese Children

- Challenges:
  - Cuff size
  - Conical shape of upper arm in obesity
  - ABPM is a valuable tool here.

At Home BP Measurement

01

-Maybe a useful adjunct after HTN has been diagnosed.

02

-Appears to be more reproducible.

03

-Inaccuracies can occur

04

-Only a few automated devices have been validated in children.

05

-Limited cuff sizes.

At- School Measurements

- -No established protocols
- -Insufficient evidence
- -Cannot be used alone to diagnose HTN
- -Can be a helpful adjunct to screen and to monitor treatment.

Primary HTN

-Is the predominant form in children in the US

-Outside the United States primary hypertension is still uncommon

-General characteristics of children with primary hypertension
  -Older age > 6 years
  -Positive family history
  -Overweight or obesity

Primary HTN

- Severity of blood pressure elevation not significantly different in children with primary versus secondary hypertension.

- Diastolic hypertension appears to be more predictive of secondary hypertension where a systolic hypertension appears to be more predictive of primary hypertension

- Children > 6 years of age do not require an extensive evaluation for secondary causes with:

  -Positive family history

  -Overweight or obese

  -No history or physical exam findings to suggest secondary causes of hypertension.

Secondary HTN: Renovascular

-Among the most common causes of secondary hypertension in children

-More common in younger children

Secondary HTN: Cardiac

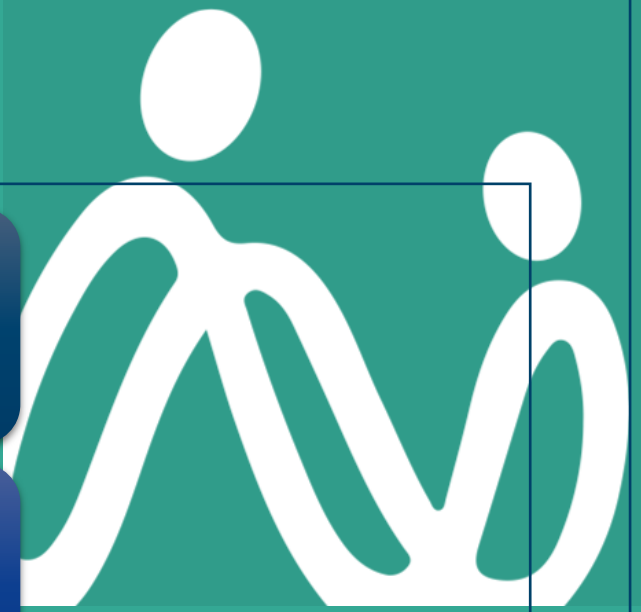
-Coarctation of the aorta
-Children with abdominal aortic obstruction may have NF, Williams, Allagile, or Takayasu arteritis.
-Suspect in children with Turner syndrome.

-May remain hypertensive or develop HTN even after early and successful repair.
-May develop HTN due to re-coarctation after repair.
-High incidence of masked HTN. Up to 45%.
-Ambulatory measurement is the **gold standard** for diagnosing HTN after coarctation repair.

Secondary HTN: Endocrine

- -Account for a small proportion of secondary HTN in children.

Secondary HTN:
Environmental exposures



-Lead

-Cadmium: batteries, electroplating, environment pollution from factories.

-Mercury

-Phthalates: Added to plastics to increase flexibility (Food, cosmetics, shampoo, enteric coated tabs)

Secondary HTN: Neurofibromatosis-1

Several unique and potential secondary causes of HTN:

- Renal artery stenosis.
- Coarctation of the aorta.
- Middle aortic syndrome.
- Pheochromocytoma.
- Increased incidence of idiopathic HTN.

Secondary HTN: Medication-related

- Prescription
- OTC
- Dietary products
- Recreational drugs
- Alternative therapies

Evaluation of HTN

-History: perinatal, nutrition, physical activity, psychosocial, medication, family hx.

-Physical exam.

-Laboratory

-ECG: High sensitivity, poor specificity for LVH. Very low positive predictive value for identifying LVH. (KAS: ECG is not your test if searching for LVH).

Imaging: Echocardiography:

-The relationship of LV mass to BP

-Independent and strong relationship of LVH to adverse CVD outcomes in adults

-A significant % of children and adolescents with HTN demonstrate the degree of LVH associated with adverse outcomes in adults.

Echocardiography

KAS: perform echocardiogram at the time pharmacologic treatment is being considered. LV structure and function, calculate left ventricular mass index

Repeat at 6 to 12 month intervals to assess improvement or progression of target organ damage.

LVH: LV mass > 51 g/m^2.7 for boys and girls > 8 years, and defined by LV mass > 115 g/BSA for boys and LV mass > 95 g/BSA for girls.

LV relative wall thickness > 0.42 cm indicates concentric geometry.

LV wall thickness > 1.4 cm is abnormal.

LV ejection fraction: < 53%.

Echocardiography

-The costs and benefits of incorporating echocardiography into hypertension care has not been assessed.

-Reproducibility of the results across echocardiography labs maybe sub optimal.

Vascular Structure & Function

-cIMT: Measurement methods vary, making it difficult to pool data from different studies.

-PWV: A measure of central arterial stiffness related to hard CV events in adults.

-FMD (flow mediated dilation): Endothelial function, ability of endothelium to release iNO in response to stress.

-Insufficient normative data available to define cut points for normal and abnormal values of these parameters.

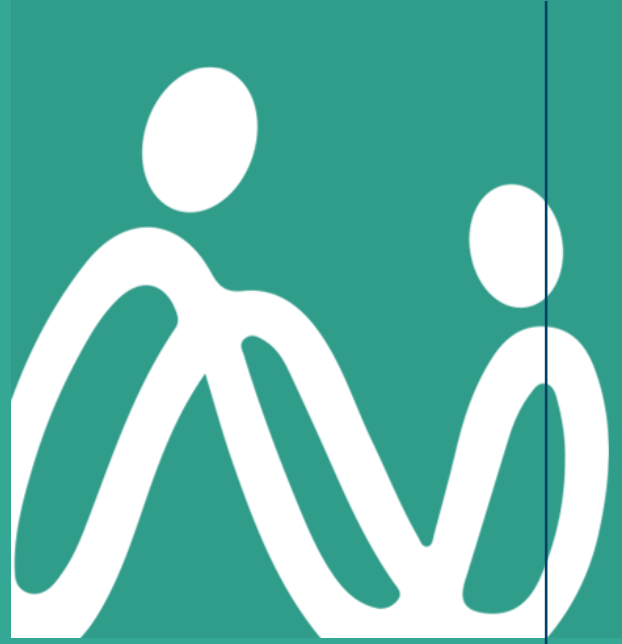
-Routine use to stratify risk in hypertensive youth is not recommended at this time.

Imaging for Renovascular Disease

- No evidence-based criteria exist to identify children who may have RAS.

- Evaluate in:
  - Stage 2 HTN,
  - Significant diastolic HTN,
  - HTN and ↓K.
  - Kidney size discrepancy on US.
  - Kidney bruits on exam.

Renal Ultrasound



Noninvasive screening study.

Accuracy varies considerably

Patient cooperation

Technician experience

Age of child, best > 8 years.

BMI

Other Imaging for RAS

-CTA: sensitivity 94%, specificity 93%. Significant radiation.

-MRA: sensitivity 90%, specificity 94%. Sedation/anesthesia required.

-Nuclear Renography: Shows reduced blood flow to affected kidney before and after administration of RAAS agent. Generally abandoned in children. Has low utility due to complex vascular abnormalities in children compared to adults with RAS.

-Gold standard: Renal Arteriography

Uric Acid

- -↑Uric acid levels are associated with HTN
- -Causative role for UA has not been established.
- -No sufficient evidence to support routine measurement in children being evaluated for HTN.

Microalbuminemuria (MA)

-Differentiate from proteinuria in CKD.

-Is a marker of HTN-related kidney injury.

-Is a predictor of CVD in adults.

-Reduced by use of ARBs and ACEI in adults.

-Lowering MA Decreased CVD risk.

-MA in children can be an isolated finding in absence of HTN (obesity, insulin resistance, DM, dyslipidemia, after vigorous activity).

-Data in children are limited. Routine testing is not recommended.

-Some studies in children showed that lowering MA was associated with regression of LVH.

Management: Elevated BP

Lifestyle Interventions Recommendations.

Weight management as appropriate.

Repeat manual BP in 6 months.

If elevated at 12 months mark (3 separate visits), then:

Order ABPM

Diagnostic evaluation

Consider subspecialty referral.

At any point if BP normalizes then back to yearly screening at WCC.

Overall Treatment Goals

Achieve BP that reduces risk for /or reverses target organ damage.

Reducing HTN and CVD in adulthood.

KAS: Achieve SBP and DBP < 90th percentile and < 130/80 mmHg in adolescents >= years old. (Previously 95th%)

Dietary Treatment

- Dietary Approach to Stop HTN (DASH).

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 Barnes TL, Crandell JL, Bell RA, Mayer-Davis EJ, Dabelea D, Liese AD. Change in DASH diet score and cardiovascular risk factors in youth with type 1 and type 2 diabetes mellitus: the SEARCH for Diabetes in Youth study. *Nutr Diabetes*. 2013;3:e91; US Department of Health and Human Services, US Department of Agriculture. Appendix 7. Nutritional goals for age-sex groups based on dietary reference intakes and dietary guidelines recommendations. In: *2015-2020 Dietary Guidelines for Americans*. Washington, DC: US Department of Health and Human Services, US Department of Agriculture; 2015; and Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: Summary Report. *Pediatrics*. 2011;128 (suppl 5): S213–S256.

Medications

-Persistent HTN despite lifestyle modifications

-Symptomatic HTN

-Stage 2 HTN without a clear modifiable factor (e.g. obesity).

-Any stage HTN with CKD or DM.

-Left Ventricular Hypertrophy.

Methods:

01

- -Single Med start,
- uptitrate if needed at 2-4 week intervals.

02

- -Add second agent, diuretic, if maximum dose of first medication does not result in control of BP.

03

Continue lifestyle modifications

04

Goal

- Goal < 90th percentile.

- Few studies show no significant difference in effectiveness between agents.

- No clinical trials in children that have CV end points as outcomes.

- Long term studies are limited.

Choice of Agent:

- -ACE inhibitor.
- -Angiotensin Receptor blocker.
- -Long acting calcium channel blocker.
- -Thiazide diuretic.

Things to keep in mind

AA children have a less robust response to ACE, need higher doses or add thiazides early on.

BB are no longer recommended as first line for treating HTN in children.

ACE & ARB contraindicated in pregnancy.

CKD and DM: ACE & ARBs preferred.

Ongoing Monitoring is Crucial.

- -Every 4-6 weeks
- -if goals reached with meds then q 3-4 months
- -if goals reached without meds, monitor q3-6
- months.
- -adherence to therapy
- -continued motivation
- -Lab testing tailored to the patient therapy.

-Reassess target organ damage eg echocardiogram, albuminuria.

-Home BP diary

-ABPM.

Resistant HTN:

Definition: Elevated BP despite being maximized in 3 drugs of different classes.

Troubleshooting:

-At least 1 should be a diuretic.

-check on adherence.

-Aldosterone Receptor Antagonist (Spironolactone) often is an optimal additional agent in adults. Addresses volume excess & untreated hyperaldosteronism.

-Adopting these stars regimes is reasonable.

Special Populations: CKD

-BP assessment at every health visit

-ACE or ARB.

-Goal is MAP < 50th percentile by ABPM

-Regardless if apparent control in office, these patients need ABPM yearly to rule out MH.

-RAAS blockade shown to be beneficial for both BP & proteinuria, although may not be sustained effect. Rebound in 36 months in one study.

Special Populations: Diabetes

-BP evaluation at each health visit.

-BP > 130/90 mmHg associated with > four fold increase in relative risk of coronary artery disease & mortality at 1- year follow up of individuals w T1DM.

-HTN more prevalent in T2DM

-HTN develops early in T2DM & is associated with rapid onset of target organ damage.

-evidence shows poor awareness of HTN in DM.

Comorbidities:

- -Dyslipidemia
- -OSAS
- -Cognitive impairments

Sex, Racial & Ethnic considerations in choice of medication:

-Risk of HTN correlates more with obesity than with sex, race and ethnic background.

-There is insufficient evidence to use those variables in medication decision making.

Acute severe HTN:

-well above stage 2 HTN (30 or more mmHg above 95th percentile).

-Majority have secondary cause for HTN.

-Assess for acute target organ effect: ARF, CHF, stroke, etc.

Acute Severe HTN

- -Oral or iv therapy.
- -Short acting agent.
- -SLOWLY reduce BP by up to 25% of planned
- reduction in the first 8 hours
- -Remainder of reduction over the next 12-24 hours.

-Goal is to get to 95th percentile.

Severe HTN w Significant Symptoms

Oral and Intravenous Antihypertensive Medications for Acute Severe HTN

Useful for Severely Hypertensive Patients With Life-Threatening Symptoms				
Drug	Class	Dose	Route	Comments
Esmolol	β-adrenergic blocker	100–500 µg/kg per min	Intravenous infusion	Short acting, constant infusion preferred. May cause profound bradycardia
Hydralazine	Direct vasodilator	0.1–0.2 mg/kg per dose up to 0.4 mg/kg per dose	Intravenous, intramuscular	Causes tachycardia Give every 4 h when given intravenous bolus
Labetalol	α- and β-adrenergic blocker	Bolus: 0.20–1.0 mg/kg per dose up to 40 mg per dose Infusion: 0.25–3.0 mg/kg per h	Intravenous bolus or infusion	Asthma and overt heart failure are relative contraindications
Nicardipine	Calcium channel blocker	Bolus: 30 µg/kg up to 2 mg per dose Infusion: 0.5–4 µg/kg per min	Intravenous bolus or infusion	May cause reflex tachycardia. Increases cyclosporine and tacrolimus levels
Sodium nitroprusside	Direct vasodilator	Starting: 0–3 µg/kg per min Maximum: 10 µg/kg per min	Intravenous infusion	Monitor cyanide levels with prolonged (>72 h) use or in renal failure; or coadminister with sodium thiosulfate

Severe HTN w Less Symptoms

Clonidine	Central α-agonist	2–5 Mg/kg per dose up to 10 Mg/kg per dose given every 6–8 h	Oral	Adverse effects include dry mouth and drowsiness
Fenoldopam	Dopamine receptor agonist	0.2–0.5 Mg/kg per min up to 0.8 Mg/kg per min	Intravenous infusion	Higher doses worsen tachycardia without further reducing BP
Hydralazine	Direct vasodilator	0.25 mg/kg per dose up to 25 mg per dose given every 6–8 h	Oral	Half-life varies with genetically determined acetylation rates
Isradipine	Calcium channel blocker	0.05–0.1 mg/kg per dose up to 5 mg per dose given every 6–8 h	Oral	Exaggerated decrease in BP can be seen in patients receiving azole antifungal agents
Minoxidil	Direct vasodilator	0.1–0.2 mg/kg per dose up to 10 mg per dose given Q 8–12 h	Oral	Most potent oral vasodilator, long acting

HTN and the Athlete

-Do NOT restrict from sports.

-Participation will improve BP over time.

Limitations to Athletes:

-If LVH beyond athletic heart then no competitive participation until BP is normalized.

-Restrict all athletes with stage 2HTN from high static sports until BP is controlled.

-Refer to sub-specialist.

-Goal lower BP < stage 2 thresholds before participation in competitive sports.

Post Transplant Patients:

Post-Transplant Patient

- -Annual ABPM is recommended.
- -Control of blood pressure in this population is challenging.
- -Many patients will require intensified antihypertensive therapy.
- -Uncontrolled hypertension contributes to progression of renal disease in these patients.
- -Evidence that ACE inhibitors and ARB's may be superior to other agents in this population.
- -Combining ACE inhibitors and ARB's is not recommended. (Hyperkalemia and acidosis).

Looking Ahead:

Goal is to decrease the burden of adult cardiovascular disease that hypertension causes.

Pediatricians continue to do a great job of screening children for hypertension and making referrals when appropriate.

NEMOURS
CHILDREN'S HEALTH

Thank You