HTN Guidelines & Implementation

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Disclosure

• We have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider of commercial services discussed in this CME activity

• We do not intend to discuss any unapproved or investigative use of a commercial product/device in our presentation.
Educational Objectives

• Explain to families the importance of measuring blood pressure in children.
• Describe the key changes present in the new BP guidelines.
• Create strategies to incorporate the new HTN guidelines into your practice.
• Develop an evaluation strategy for children with hypertension.
• Identify the indication for and the value of specialized testing.
• Construct a plan for non-pharmacologic and pharmacologic treatment of hypertension in children.

Clinical significance of high BP

Adverse outcomes
Clinical significance of high BP - Children

Accelerated vascular aging

Onset of CV Disease begins in Childhood
45-77% showed some gross evidence of coronary arteriosclerosis

JAMA 1953:152;1090
JAMA 1971:216;1185

Indirect (surrogate) markers of CVD

Left Ventricular Hypertrophy (LVH)

Carotid Intima-media Thickness (CMIT)
Children with HTN have LVH

Nephrol Dial Transplant 2009;24:370

1 of 3

1 of 4

Children with HTN have ↑ cIMT

Pediatr 2003;111:61
Hypertension 2006;48:40
Children with HTN have lower scores on neurocognitive tests

J Pediatr 2003;143:720

Children with HTN also have:

- Arterial stiffness
- Endothelial dysfunction
- Low-grade inflammation
- Diastolic dysfunction
- Renal changes

CV Risk factors track from Childhood to adulthood

Obesity
Diabetes mellitus
Hypertension
Hyperlipidemia

J Pediatr 2001;138:469
Circulation 1978;58:626
Onset of CV Disease begins in Childhood

Gaps/Issues

- Expanded breadth of new evidence
- Normative data biased
- BP table difficult to use in practice
- Incongruence with adult guidelines
- Emergence of ABPM
Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents

Joseph T. Flynn, MD, MS, FAAP,1 David G. Kaelber, MD, PhD, MPH, FAAP, FACP, FAGS,2 Carissa M. Baker-Smith, MD, MS, MPH, FAAP, FAPA,3 Douglas Blowey, MD,4 Aaron E. Carroll, MD, MS, FAAP,5 Stephen R. Daniels, MD, PhD, FAAP,6 Sarah D. de Ferranti, MD, MPH, FAAP,7 Janis M. Dionne, MD, FRCP,8 Bonita Falkner, MD,9 Susan K. Flinn, MA,10 Samuel S. Gidding, MD,11 Celeste Goodwin,1 Michael G. Lou, MD, MS, MHS, FAAP,12 Makia E. Powers, MD, MPH, FAAP,12 Corinna Rea, MD, MPH, FAAP,13 Joshua Samuels, MD, MPH, FAAP,13 Madeline Simasok, MD, MSGP, FAAP,13 Vidhu V. Thaker, MD, FAAP,13 Elaine M. Urbina, MD, MS, FAAP,14 SUBCOMMITTEE ON SCREENING AND MANAGEMENT OF HIGH BLOOD PRESSURE IN CHILDREN

A big document!

• 8 significant changes
• 30 key action statements
• 27 additional recommendations
Goals of the updated guideline

- Patient and family centered approach
- Reduce unnecessary and costly interventions
- Improve diagnoses and outcomes
- Support implementation
- Provide direction for future research

Revised Definitions

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

Previously called prehypertension

Changed from +5 to +12

Adult values used now for teens
New Blood Pressure Tables

- Based on normal weight children only
- Cutoffs are lower than in the Fourth Report tables
- Complete tables include the actual heights, and have the cutoffs for the actual categories
## Screening BP Values

| 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   |

Screening table is based off the 90th percentile for BP and the 5th percentile for height.

## Apps

![Pediatric Blood Pressure](image-url)

**Pediatric Blood Pressure**

- **Clinical Practice Guideline Tool**
- **Age**: 7 yr
- **Height**: 123.6 cm
- **Percentiles**:
  - 50th: 97 / 58
  - 60th: 109 / 70
  - 70th: 112 / 73
  - 80th: 124 / 85

**Apps**

- **Medical**
  - **Apps**
    - **Pediatric Blood Pressure**
      - *Clinical Practice Guideline Tool*
      - **Age**: 7 yr
      - **Height**: 123.6 cm
      - **Percentiles**:
        - 50th: 97 / 58
        - 60th: 109 / 70
        - 70th: 112 / 73
        - 80th: 124 / 85
When to measure BP

- Annually ages 3 and up
- From birth, every visit, for high risk patients
  - Obese
  - Kidney disease, urologic malformations, FH of renal disease
  - Coarctation, Congenital Heart Disease, repaired or not
  - Diabetes
  - Prematurity <32 weeks, SGA, VLBW, history of umbilical lines
  - Recurrent UTIs, hematuria, proteinuria
  - Malignancy, solid organ transplant, bone marrow transplant
  - On medications associated with increased BP
  - Systemic disease associated with increased BP

Measurement methods

- **Manual** vs. Oscillometric
- Forearm or wrist- not recommended
- Ambulatory blood pressure monitoring
  - White coat hypertension
  - Masked hypertension
- Home monitoring
Measurement best practices

- Child should be seated for 3-5 minutes in a quiet room, back supported, feet uncrossed on the floor.
- Right arm (unless unusual aortic anatomy)
- At heart level, supported, uncovered above the cuff
- Correct cuff size- bladder length 80-100% of the circumference, width at least 40%
- For leg measurements, patient should be prone, cuff at mid-thigh, auscultation over popliteal artery.

Modified BP measurement algorithm.

## Blood pressure follow up

<table>
<thead>
<tr>
<th>Stage</th>
<th>Next steps</th>
<th>Recheck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Recheck annually</td>
<td></td>
</tr>
<tr>
<td>Elevated</td>
<td>Lifestyle changes</td>
<td>Recheck in 6 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If still high after 12 months, ABPM</td>
</tr>
<tr>
<td>Stage 1</td>
<td>Lifestyle changes</td>
<td>Recheck in 1-2 wks, and if still high, recheck in 3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If still high after 3 visits, ABPM, evaluation, referral, and treatment</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Lifestyle changes</td>
<td>Recheck or refer in 1 week</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If persistent, treat. If symptomatic, or &gt;30% above 95th, or &gt;180/120, send to ED for immediate care</td>
</tr>
</tbody>
</table>

### Ambulatory blood pressure monitoring (ABPM)

ABPM is a noninvasive way of obtaining BP over a 24-hour period while the patient is in their own environment, representing a true reflection of their blood pressure.

- Useful tool to assess BP pattern
- Not required to make diagnosis of HTN
- Patient required to get ABPM followed by specialists.
Evaluation

- Etiology
- Associated comorbidity
- Effect of HTN: Target organ damage
- For monitoring the effects of treatment/intervention
Primary vs secondary HTN

• Primary
• Secondary:
  – Renal or renovascular
  – Cardiac: COA and arch anomaly
  – Endocrine
  – Environmental
  – medication

Evaluation

• History
• Physical examination
• Lab evaluation
  — EKG
• Echocardiogram
• Imaging for renovascular disease
• Vascular structure and function
History

- Perinatal History
- Nutritional history
- Physical activity history
- Psychosocial history
- Family history

Evaluation: History

- KAS 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).*
### History and PE

#### Table 2 (continued)

<table>
<thead>
<tr>
<th>Body System</th>
<th>Finding, History</th>
<th>Possible Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vital signs</strong></td>
<td>Tachycardia</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>Hyperthyroidism</td>
<td>CBC</td>
</tr>
<tr>
<td></td>
<td>Decreased lower extremity pulses, drop in BP from upper to lower extremities</td>
<td>Neuroblastoma</td>
</tr>
<tr>
<td><strong>Eyes</strong></td>
<td>Proptosis</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>Retinal changes*</td>
<td>Severe HTN, more likely to be associated with secondary HTN</td>
</tr>
<tr>
<td><strong>Ear, nose, throat</strong></td>
<td>Adenotonsillar hypertrophy</td>
<td>SDB</td>
</tr>
<tr>
<td></td>
<td>History of snoring</td>
<td>Sleep apnea</td>
</tr>
<tr>
<td><strong>Height, weight</strong></td>
<td>Growth retardation</td>
<td>Chronic renal failure</td>
</tr>
<tr>
<td></td>
<td>Obesity (high BMI)</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td><strong>Head, neck</strong></td>
<td>Genu faciei</td>
<td>Williams syndrome</td>
</tr>
<tr>
<td></td>
<td>Moon facies</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td></td>
<td>Thryromeгляy, goiter</td>
<td>Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>Webbed neck</td>
<td>Turner syndrome</td>
</tr>
<tr>
<td><strong>Skin</strong></td>
<td>Pallor, flushing, diaphoresis</td>
<td>PCC</td>
</tr>
<tr>
<td></td>
<td>Acne, hirsutism, striae</td>
<td>Cushing syndrome</td>
</tr>
<tr>
<td></td>
<td>Café-au-lait spots</td>
<td>Neurofibromatosis</td>
</tr>
<tr>
<td></td>
<td>Adenoma sebaceum</td>
<td>Tubular sclerosis</td>
</tr>
<tr>
<td><strong>Hematologic</strong></td>
<td>Pallor</td>
<td>Renal disease</td>
</tr>
<tr>
<td></td>
<td>Sickle cell anemia</td>
<td>Renal disease</td>
</tr>
<tr>
<td><strong>Chest, cardiac</strong></td>
<td>Chest pain</td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td>Palpitations</td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td>Exertional dyspnea</td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td>Widely spaced nipples</td>
<td>Turner syndrome</td>
</tr>
<tr>
<td></td>
<td>Heart murmur</td>
<td>Coarctation of the aorta</td>
</tr>
<tr>
<td></td>
<td>Friction rub</td>
<td>Systemic lupus (pericarditis)</td>
</tr>
<tr>
<td></td>
<td>Apical heave*</td>
<td>Collagen vascular disease</td>
</tr>
<tr>
<td><strong>Abdomen</strong></td>
<td>Abdominal mass</td>
<td>LVN</td>
</tr>
<tr>
<td></td>
<td>Wilms tumor</td>
<td>Neuroblastoma</td>
</tr>
<tr>
<td></td>
<td>Epigastric, flank pain</td>
<td>PCC</td>
</tr>
<tr>
<td></td>
<td>Palpable kidneys</td>
<td>RCC</td>
</tr>
<tr>
<td></td>
<td>Ambiguous or virilized genitalia</td>
<td>Congenital adrenal hyperplasia</td>
</tr>
<tr>
<td><strong>Genitourinary</strong></td>
<td>Urinary tract infection</td>
<td>Hydro nephrosis</td>
</tr>
<tr>
<td></td>
<td>Vesicoureteral reflux</td>
<td>Multicystic dysplastic kidney</td>
</tr>
<tr>
<td></td>
<td>Hematuria, edema, fatigue</td>
<td>Multicystic dysplastic kidney</td>
</tr>
<tr>
<td><strong>Extremities</strong></td>
<td>Joint swelling</td>
<td>Systemic lupus</td>
</tr>
<tr>
<td></td>
<td>Muscle weakness</td>
<td>Collagen vascular disease</td>
</tr>
<tr>
<td><strong>Neurologic, metabolic</strong></td>
<td>Hypokalemia, headache, dizziness, polyuria, nocturia</td>
<td>Hyperaldosteronism</td>
</tr>
<tr>
<td></td>
<td>Muscle weakness, hypokalemia</td>
<td>Liddle syndrome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reninoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monogenic HTN (Liddle syndrome, OCA, AHO)</td>
</tr>
</tbody>
</table>
Labs and imaging

Who needs extensive evaluation?

• KAS 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).
Cardiac specific evaluation

- For etiology: COA, re-COA
- Evaluation of target organ damage
- Monitoring of the effects of treatment/ intervention
How about EKG

When to do EKG

• KAS 19
  – Clinicians should not perform electrocardiography (ECG) in hypertensive children and adolescents being evaluated for LVH.
Echocardiogram:

- KAS 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 g/m².7 (boys and girls) for children and adolescents older than 8 years and defined by LV mass >115 g/BSA for boys and LV mass >95 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).

Echocardiogram:

- LVH is defined as left ventricular mass, indexed >51 g/m².7 or LVM >115 g/body surface area (BSA) for boys and LVM >95 g/BSA for girls. An LV RWT >0.42 indicates concentric geometry. LV wall thickness >1.4 cm is abnormal.
- Decreased LV EF is a value <53%
Coarctation of Aorta

• HTN
• BP gradient (UL to LL)
• RF delay
• Systolic murmur interscapular region
• Ejection click (BAV and associated COA)
• Suspicion of genetic condition conditions such as Turners, Williams
• Abdominal COA: neurofibromatosis, Williams syndrome, Alagille syndrome, or Takayasu arteritis.

Coarctation of Aorta repair: BP monitoring

• KAS 12:
  – Children and adolescents who have undergone coarctation repair should undergo ABPM for the detection of HTN (including MH) (grade B, strong recommendation).
Renal and renovascular imaging:

- **KAS 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).

- **KAS: 17**
  - In children and adolescents suspected of having RAS, either CTA or MRA may be performed as a noninvasive imaging study. Nuclear renography is less useful in pediatrics and should generally be avoided (grade D, weak recommendation).

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**HTN and Athletes**
HTN and Athletes

Just need sports clearance

But I have football game tonight???
HTN and Athletes

- Sports participation should be encouraged
- Exercise has beneficial effects in HTN and cardiac structure
- No data linking the HTN to sudden death related to sports in children
- BUT; many cases of sudden death are unknown etiology
AHA/ACC

- limit competitive athletic participation among athletes with LVH beyond that seen with athlete’s heart until BP is normalized by appropriate antihypertensive drug therapy,

- restricting athletes with stage 2 HTN (even among those without evidence of target organ injury) from participating in high-static sports (eg, weight lifting, boxing, and wrestling) until HTN is controlled with either lifestyle modification or drug therapy.
## HTN and Athletes

- **KAS28:**
  - Children and adolescents with HTN may participate in competitive sports once hypertensive target organ effects and risk have been assessed (grade C, moderate recommendation).

- **KAS 29:**
  - Children and adolescents with HTN should receive treatment to lower BP below stage 2 thresholds before participating in competitive sports (grade C, weak recommendation).

## Treatment
Who?

Any child with an abnormal blood pressure

>90th % ‘tile

>120/80 mmHg

Why?

Prevention of pediatric morbidity associated with hypertension

Prevention of adult onset cardiovascular disease
Who needs medication?

- Persistent Stage 1 HTN after 6-12 months of lifestyle modifications
- Symptomatic HTN
- Stage 2 HTN without a clear modifiable risk factor
- HTN with CKD or DM
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.

KAS 14: Treatment goals

KAS 21

- Angiotension Converting Enzyme (ACE) inhibitor
- Angiotension Receptor Blocker (ARB)
- Long-acting Calcium channel blocker
- Thiazide diuretic
Drug treatment considerations

- ACE/ARB – may not be as effective in African Americans
- ACE/ARB – preferred in CKD and DM
- ACE/ARB – associated with fetal toxicity
### Angiotensin converting enzyme inhibitor

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Pregnancy, angioedema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common AE’s</td>
<td>Cough, headache, dizziness, asthenia</td>
</tr>
<tr>
<td>Severe AE’s</td>
<td>Hyperkalemia, acute kidney injury, angioedema, fetal toxicity</td>
</tr>
<tr>
<td>Drugs</td>
<td>Benazepril*, Captopril, Enalapril*, Fosinopril*, Lisinopril*, Ramipril, Quinapril</td>
</tr>
</tbody>
</table>

* FDA Pediatric Labeling

### Angiotensin receptor blocker

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common AE’s</td>
<td>headache, dizziness</td>
</tr>
<tr>
<td>Severe AE’s</td>
<td>Hyperkalemia, acute kidney injury, fetal toxicity</td>
</tr>
<tr>
<td>Drugs</td>
<td>Candesartan*, Irbesartan, Losartan*, Olmesartan*, Valsartan*</td>
</tr>
</tbody>
</table>

* FDA Pediatric Labeling
### Thiazide diuretics

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>anuria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common AE's</td>
<td>dizziness, hypokalemia</td>
</tr>
<tr>
<td>Severe AE's</td>
<td>Cardiac dysrhythmias, cholesterics jaundice, new onset diabetes mellitus, pancreatitis</td>
</tr>
<tr>
<td>Drugs</td>
<td>Chlorthalidone, Chlorothiazide*, Hydrochlorothiazide*</td>
</tr>
</tbody>
</table>

* FDA Pediatric Labeling

### Long-acting calcium channel blockers

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Hypersensitivity to CCB’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common AE’s</td>
<td>Flushing, peripheral edema, dizziness</td>
</tr>
<tr>
<td>Severe AE’s</td>
<td>angioedema</td>
</tr>
<tr>
<td>Drugs</td>
<td>Amlodipine*, Felodipine, Isradipine (ER), Nifedipine (ER)</td>
</tr>
</tbody>
</table>

* FDA Pediatric Labeling
Summary

- CV disease begins in childhood
- All children with elevated BP should be “treated”
- HTN is defined as BP >95th %tile or 130/80 mmHg
- Most children do not have an identifiable cause of HTN but an identifiable cause is more likely in children < 6 years of age or those with severe HTN
- An extensive evaluation is not needed for most children with HTN
- Treatment options include lifestyle modifications (all) and antihypertensive medications (ACE, ARB, Thiazide, CCB)

AAP HTN Guideline
http://pediatrics.aappublications.org/content/early/2017/08/21/peds.2017-1904

General information
https://kidshealth.org/ChildrensMercy/en/#catfitness

DASH diet resource
Key References


Thank You
Questions?