The 4th Report on High Blood Pressure in Children and Adolescents
Working Group on High Blood Pressure in Children and Adolescents

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*Joseph T. Flynn, MD, MS, is a paid contributor to Pfizer, Inc, Novartis Pharmaceuticals, AstraZeneca, Inc, and ESP-Pharma.
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American Diabetes Association
American Dietetic Association
American Heart Association
American Hospital Association
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American Nurses Association
American Optometric Association
American Osteopathic Association
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National Heart, Lung, and Blood Institute
National Institute of Diabetes and Digestive and Kidney Diseases
Introduction

- Purpose
  - To update clinicians on the latest scientific evidence regarding blood pressure in children
  - To provide recommendations for diagnosis, evaluation, and treatment of hypertension
Overview

- New national data have been added to the childhood BP database.
- Updated BP tables now include the 50th, 90th, 95th, and 99th percentiles by sex, age, and height.
- Hypertension in children and adolescents continues to be defined as systolic BP (SBP) and/or diastolic BP (DBP) that is, on repeated measurement, at or above the 95th percentile. BP between the 90th and 95th percentile is now termed “prehypertensive.”
Overview

- The rationale for identification of early target-organ damage in children and adolescents with hypertension is provided.
- Revised recommendations for use of antihypertensive drug therapy are provided.
- Treatment recommendations include nonpharmacologic therapies and reduction of other cardiovascular risk factors.
- Information is included on the identification of sleep disorders in some hypertensive children.
Methods

- The NHBPEP Coordinating Committee (CC) suggested updating the 1996 Working Group Report on Hypertension in Children and Adolescents.
- Prominent pediatric clinicians and scholars were selected to review available scientific evidence and submit manuscripts.
- The NHLBI Director appointed a working group to revise the report.
Methods

- Scientific evidence was classified in a process adapted from Last and Abramson (JNC 7).
- A draft was sent to the NHBPEP CC for review and vote.
- The report was published in the August 2004 supplement of *Pediatrics*. 
Definition of Hypertension

- **Hypertension**—average SBP and/or DBP that is greater than or equal to the 95th percentile for sex, age, and height on 3 or more occasions.

- **Prehypertension**—average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile.
  - Adolescents with BP levels greater than or equal to 120/80 mmHg should be considered prehypertensive.
Definition of Hypertension

- **White-coat hypertension**—A patient with BP levels above the 95th percentile in a physician’s office or clinic who is normotensive outside a clinical setting. (Ambulatory BP monitoring is usually required to make this diagnosis.)
Measurement of Blood Pressure in Children

- Children >3 years old should have their BP measured.
- Auscultation is the preferred method of BP measurement.
- Correct measurement requires a cuff that is appropriate to the size of the child’s upper arm.
- Elevated BP must be confirmed on repeated measurement.
- BP >90th percentile obtained by oscillometric devices should be repeated by auscultation.
Conditions Under Which Children <3 Years Old Should Have BP Measured

- History of prematurity, very low birthweight, or other neonatal complication requiring intensive care
- Congenital heart disease, whether repaired or nonrepaired
- Recurrent urinary tract infections, hematuria, or proteinuria
- Known renal disease or urologic malformations
- Family history of congenital renal disease
Conditions Under Which Children <3 Years Old Should Have BP Measured

- Solid organ transplant
- Malignancy or bone marrow transplant
- Treatment with drugs known to raise BP
- Other systemic illnesses associated with hypertension
- Evidence of elevated intracranial pressure
## Recommended Dimensions for Blood Pressure Cuff Bladders

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Width (cm)</th>
<th>Length (cm)</th>
<th>Maximum Arm Circumference (cm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>4</td>
<td>8</td>
<td>10</td>
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<tr>
<td>Infant</td>
<td>6</td>
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<td>Child</td>
<td>9</td>
<td>18</td>
<td>22</td>
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<tr>
<td>Small adult</td>
<td>10</td>
<td>24</td>
<td>26</td>
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<tr>
<td>Adult</td>
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<tr>
<td>Large adult</td>
<td>16</td>
<td>38</td>
<td>44</td>
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<tr>
<td>Thigh</td>
<td>20</td>
<td>42</td>
<td>52</td>
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</tbody>
</table>

*Calculated so that the largest arm would still allow the bladder to encircle the arm by at least 80 percent.
Ambulatory Blood Pressure Monitoring

- Is useful in the evaluation of:
  - White-coat hypertension
  - Target-organ injury risk
  - Apparent drug resistance
  - Drug-induced hypotension.

- Provides additional BP information in:
  - Chronic kidney disease
  - Diabetes
  - Autonomic dysfunction.

- Should be performed by clinicians experienced in its use and interpretation.
Blood Pressure Tables

- BP standards based on sex, age, and height provide a precise classification of BP according to body size.

- The revised BP tables now include the 50th, 90th, 95th, and 99th percentiles by sex, age, and height.
<table>
<thead>
<tr>
<th>Age (Year) Percentile</th>
<th>BP Percentile</th>
<th>SBP (mmHg)</th>
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<td>Age (Year) Percentile</td>
<td>SBP (mmHg)</td>
<td>DBP (mmHg)</td>
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<td>5th 10th 25th 50th 75th 90th 95th</td>
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<td>59 60 61 62 63 63 64</td>
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<td>90th</td>
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<td>95th</td>
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<tr>
<td>99th</td>
<td>126 127 129 131 133 134 135</td>
<td>86 87 88 89 90 90 91</td>
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</tbody>
</table>
How To Use the BP Tables

1. Use the standard height charts to determine the height percentile.

2. Measure and record the child’s SBP and DBP.

3. Use the correct gender table for SBP and DBP.

4. Find the child’s age on the left side of the table. Follow the age row horizontally across the table to the intersection of the line for the height percentile (vertical column).
How To Use the BP Tables

5. For SBP percentiles in the left columns and for DBP percentiles in the right columns:

- **Normal BP** = <90th percentile.
- **Prehypertension** = BP between the 90th and 95th percentile or ≥120/80 mmHg in adolescents.
- **Hypertension** = BP >95th percentile on repeated measurement.
6. BP >90th percentile should be repeated twice at the same office visit.
7. BP >95th percentile should be staged:
   - Stage 1 = the 95th percentile to the 99th percentile plus 5 mmHg.
   - Stage 2 = >99th percentile plus 5 mmHg.
<table>
<thead>
<tr>
<th>SBP or DBP Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>&lt;90\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>Prehypertension</td>
</tr>
<tr>
<td>90\textsuperscript{th} percentile to &lt;95\textsuperscript{th} percentile, or if BP exceeds 120/80 even if below the 90th percentile up to &lt;95\textsuperscript{th} percentile</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
</tr>
<tr>
<td>95\textsuperscript{th} percentile to the 99\textsuperscript{th} percentile plus 5 mmHg</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
</tr>
<tr>
<td>&gt;99\textsuperscript{th} percentile plus 5 mmHg</td>
</tr>
<tr>
<td>Classification of Hypertension in Children and Adolescents, With Measurement Frequency and Therapy Recommendations</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of BP Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>Prehypertension</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
</tr>
</tbody>
</table>

**Normal**
- Recheck at next scheduled physical examination.

**Prehypertension**
- Recheck in 6 months.

**Stage 1 hypertension**
- Recheck in 1–2 weeks or sooner if the patient is symptomatic; if BP is persistently elevated on two additional occasions, evaluate or refer to source of care within 1 month.

**Stage 2 hypertension**
- Evaluate or refer to source of care within 1 week or immediately if the patient is symptomatic.
**Classification of Hypertension in Children and Adolescents, With Measurement Frequency and Therapy Recommendations**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Therapeutic Lifestyle Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Encourage healthy diet, sleep, and physical activity.</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>Recommend weight management counseling if overweight; introduce physical activity and diet management.</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
<td>Recommend weight management counseling if overweight; introduce physical activity and diet management.</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>Recommend weight management counseling if overweight; introduce physical activity and diet management.</td>
</tr>
<tr>
<td>Classification</td>
<td>Pharmacologic Therapy</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td>Normal</td>
<td>None</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>Do not initiate therapy unless there are compelling indications such as chronic kidney disease (CKD), diabetes mellitus, heart failure, left ventricular hypertrophy (LVH).</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
<td>Initiate therapy based on indications for antihypertensive drug therapy or if there are compelling indications as above.</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>Initiate therapy.</td>
</tr>
</tbody>
</table>
Indications for Antihypertensive Drug Therapy in Children

- Symptomatic hypertension
- Secondary hypertension
- Hypertensive target-organ damage
- Diabetes (types 1 and 2)
- Persistent hypertension despite nonpharmacologic measures
# Clinical Evaluation of Confirmed Hypertension

<table>
<thead>
<tr>
<th>Study or Procedure</th>
<th>Purpose</th>
<th>Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaluation for identifiable causes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>History, including sleep history, family history, risk factors, diet, and habits such as smoking and drinking alcohol; physical examination</td>
<td>History and physical examination help focus subsequent evaluation</td>
<td>All children with persistent BP &gt;95th percentile</td>
</tr>
<tr>
<td>BUN, creatinine, electrolytes, urinalysis, urine culture</td>
<td>R/O renal disease and chronic pyelonephritis</td>
<td>All children with persistent BP &gt;95th percentile</td>
</tr>
<tr>
<td>CBC</td>
<td>R/O anemia, consistent with chronic renal disease</td>
<td>All children with persistent BP &gt;95th percentile</td>
</tr>
<tr>
<td>Renal ultrasound</td>
<td>R/O renal scar, congenital anomaly, or disparate renal size</td>
<td>All children with persistent BP &gt;95th percentile</td>
</tr>
</tbody>
</table>
Clinical Evaluation of Confirmed Hypertension

<table>
<thead>
<tr>
<th>Study or Procedure</th>
<th>Purpose</th>
<th>Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation for comorbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasting lipid panel, fasting</td>
<td>To identify hyperlipidemia, identify metabolic abnormalities</td>
<td>Overweight patients with BP at 90th–94th percentiles; all</td>
</tr>
<tr>
<td>glucose</td>
<td></td>
<td>patients with BP &gt;95th percentile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Family history of hypertension or cardiovascular disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child with chronic renal disease</td>
</tr>
<tr>
<td>Drug screen</td>
<td>To identify substances that might cause hypertension</td>
<td>History suggestive of possible contribution by substances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or drugs</td>
</tr>
<tr>
<td>Polysomnography</td>
<td>To identify sleep disorder in association with hypertension</td>
<td>History of loud, frequent snoring</td>
</tr>
</tbody>
</table>
# Clinical Evaluation of Confirmed Hypertension

## Study or Procedure

- **Evaluation for target-organ damage**

<table>
<thead>
<tr>
<th>Study or Procedure</th>
<th>Purpose</th>
<th>Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiogram</td>
<td>Identify LVH and other indications of cardiac involvement</td>
<td>Patients with comorbid risk factors* and BP at the 90th–94th percentiles; all patients with BP &gt;95th percentile</td>
</tr>
<tr>
<td>Retinal examination</td>
<td>Identify retinal vascular changes</td>
<td>Patients with comorbid risk factors and BP at the 90th–94th percentiles; all patients with BP &gt;95th percentile</td>
</tr>
</tbody>
</table>

## Further evaluation as indicated

- **Ambulatory BP monitoring**

<table>
<thead>
<tr>
<th>Study or Procedure</th>
<th>Purpose</th>
<th>Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambulatory BP monitoring</td>
<td>Identify white-coat hypertension, abnormal diurnal BP pattern, BP load</td>
<td>Patients in whom white-coat hypertension is suspected, and when other information on BP pattern is needed</td>
</tr>
</tbody>
</table>

*Comorbid risk factors also include diabetes mellitus and kidney disease
# Clinical Evaluation of Confirmed Hypertension

<table>
<thead>
<tr>
<th>Study or Procedure</th>
<th>Purpose</th>
<th>Target Population</th>
</tr>
</thead>
</table>
| Plasma renin determination         | Identify low renin, suggesting mineralocorticoid-related disease | Young children with stage 1 hypertension and any child or adolescent with stage 2 hypertension  
Positive family history of severe hypertension |
| Renovascular imaging               | Identify renovascular disease                     | Young children with stage 1 hypertension and any child or adolescent with stage 2 hypertension |
| Plasma and urine steroid levels    | Identify steroid-mediated hypertension            | Young children with stage 1 hypertension and any child or adolescent with stage 2 hypertension |
| Plasma and urine catecholamines    | Identify catecholamine-mediated hypertension      | Young children with stage 1 hypertension and any child or adolescent with stage 2 hypertension |
Primary Hypertension and Evaluation for Comorbidities

- Primary hypertension is identifiable in children and adolescents.
- Hypertension and prehypertension are significant health issues in the young due to the marked increase in the prevalence of overweight children.
- The evaluation of hypertensive children should include assessment for additional risk factors.
Secondary hypertension is more common in children than in adults.

Body Mass Index (BMI) should be calculated as part of the physical examination.

When hypertension is confirmed, BP should be measured in both arms and a leg.
Evaluation for Secondary Hypertension

- Children or adolescents with stage 2 hypertension, and very young children with stage 1 or stage 2 hypertension should be evaluated more completely.
- A comprehensive medical history should be obtained.
- History of drug and substance use should be included.
Evaluation for Secondary Hypertension

- A sleep history should be obtained. (There is an association of sleep apnea with overweight and high BP.)
- Family history should include history of hypertension and other cardiovascular disease.
Renin Profiling

Plasma renin level or plasma renin activity (PRA) is a useful screening test for mineralocorticoid-related diseases.
Evaluation for renovascular disease also should be considered in infants or children with other known predisposing factors, such as prior umbilical artery catheter placements or neurofibromatosis.
Invasive Studies

Digital subtraction angiography and formal arteriography are still considered the “gold standard,” but these studies should be undertaken only when surgical or invasive interventional radiologic techniques are being contemplated for anatomic correction.
Target-Organ Abnormalities in Children with Hypertension

- Target-organ abnormalities are detectable in hypertensive children and adolescents.
- LVH is the most prominent evidence of target-organ damage.
- Echocardiographic assessment of left ventricular mass should be performed at diagnosis of hypertension and periodically thereafter.
- The presence of LVH is an indication to initiate or intensify antihypertensive therapy.
Clinical Recommendation

- Echocardiography is the recommended primary tool for detection of target-organ abnormalities.
- Children and adolescents with established hypertension should have an echocardiogram to determine if LVH is present.
- Echocardiographic measurements are used to calculate the left ventricular mass index.
LV Mass (g) =
0.80 \left[1.04\ (IVS + LVED + LVPW)^3 - (LVED)^3\right] + 0.6

Echocardiographic measurements are in cm.
Left Ventricular Hypertrophy

- Left ventricular mass is indexed by height in meters 2.7.
- A conservative cutpoint that defines LVH is 51 g/m^{2.7}.
- For patients who have LVH, the echocardiographic determination of the left ventricular mass index should be repeated periodically.
Therapeutic Lifestyle Changes

- Weight reduction is the primary therapy for obesity-related hypertension. Prevention of excess weight gain can limit future increases in BP.

- Physical activity can improve efforts at weight management and may prevent future increase in BP.
Dietary modification should be strongly encouraged in children and adolescents with prehypertension, as well as those with hypertension.

Family-based intervention improves success.
Indications for antihypertensive drug therapy in children include secondary hypertension and insufficient response to lifestyle modifications.

Recent clinical trials have expanded the number of drugs that have pediatric dosing information.

Pharmacologic therapy should be initiated with a single drug.
The goal for antihypertensive treatment in children should be reduction of BP to <95th percentile, unless concurrent conditions are present. In that case, BP should be lowered to <90th percentile.

Severe, symptomatic hypertension should be treated with intravenous antihypertensive drugs.
Measure BP and Height and Calculate BMI
Determine BP category for sex, age, and height

**Stage 2 Hypertension**
- Diagnostic Workup Includes Evaluation for Target-Organ Damage
- Secondary Hypertension
- Primary Hypertension
- Consider Referral To provider with expertise in pediatric hypertension
- Normal BMI
- Overweight
  - Drug Rx
  - Weight Reduction and Drug Rx

**Stage 1 Hypertension**
- Diagnostic Workup Includes Evaluation for Target-Organ Damage
- Secondary Hypertension
- Primary Hypertension
  - Rx Specific for Cause
  - Therapeutic Lifestyle Changes
  - ≥95%
    - Still ≥95%
      - Drug Rx
      - Weight Reduction
  - Normal BMI
  - Overweight
    - Normal BMI
    - Overweight

**Prehypertensive**
- Therapeutic Lifestyle Changes
  - 90–<95% or 120/80 mmHg
  - 90–<95% or 120/80 mmHg

**Normotensive**
- Educate on Heart Healthy Lifestyle For the family
- Repeat BP In 6 months

**Management Algorithm**
- Consider Diagnostic Workup and Evaluation for Target-Organ Damage If overweight or comorbidity exists
- Monitor Q 6 Mo
  - Normal BMI
  - Overweight
  - Weight Reduction
Educational Materials

- Web Site [www.nhlbi.nih.gov](http://www.nhlbi.nih.gov)
- Pediatric Hypertension Clinical Reference Tool for Palm OS
- Complete Report
- Slide Show
The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7)

The Guidelines

- JNC 7 Express
- JNC 7 Full Report—printed version
  - PubMed Abstract

Information for Patients

- My Blood Pressure Wallet Card
- Your Guide to Lowering Blood Pressure
- Facts About the DASH Eating Plan
  (revised, May 2003)

Information for Health Professionals

- 4th Report on High Blood Pressure in Children and Adolescents
- JNC 7 Application for Palm OS and PocketPC
- Physician Reference Card
- Slide Show
Clinical Reference Tool for Palm OS

- Interactive tool to assist the clinician in implementing the reports recommendations
- Available at: http://www.nhlbi.nih.gov


Download our Pediatric Hypertension Clinical Reference Tool for Palm OS

The Palm OS (Operating System) program for application of the 4th Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents is now available.

This interactive guideline tool will assist the clinician in implementing the 4th Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents at the point of care.

Instructions for installing the Clinical Reference Application Program your Palm OS device:
Complete Report

- Available as National Heart, Lung, and Blood Institute Publication No. 56-091N. 2004