Hypertension and Ambulatory Blood Pressure Monitoring in Children

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Pediatric Nephrology
Hackensack University Medical Center
Hypertension

A topic near and dear to my...
Recognizing Hypertension in Children is important because...

- ~3% of U.S. children (up to 45% of obese children)
- sign of underlying disease
- end organ damage
- beginning of adult essential HTN
Causes of Elevated BP in Children

- Pain or Fear
- Medications (steroids, tacrolimus)
- Renal issues
- Vascular problems
- Fluid overload
- Obesity-related/Metabolic Syndrome
- Essential
### Causes of HTN at Great Ormond Street Hospital for Children

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflux &amp; obstructive uropathy (scarring)</td>
<td>36%</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>23%</td>
</tr>
<tr>
<td>Renovascular disease</td>
<td>9.5%</td>
</tr>
<tr>
<td>Coarctation of the aorta</td>
<td>8.9%</td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td>5.5%</td>
</tr>
<tr>
<td>Post-Hemolytic Uremic Syndrome</td>
<td>4.0%</td>
</tr>
<tr>
<td>Idiopathic/Essential</td>
<td>3.4%</td>
</tr>
<tr>
<td>Catecholamine excess states</td>
<td>2.8%</td>
</tr>
<tr>
<td>Wilms Tumor</td>
<td>2.4%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4.6%</td>
</tr>
</tbody>
</table>
How Do We Check BP in Children?
Measurement of Blood Pressure in Children

- Children >3 years old should have their BP measured
- Auscultation is the preferred method of BP measurement
- Elevated BP must be confirmed on repeated measurement
- BP >90th percentile obtained by oscillometric devices should be repeated by auscultation
Measurement of Blood Pressure in Children

- Correct measurement requires a cuff that is appropriate to the size of the child’s upper arm.
  - Main source of error – Using wrong cuff size
  - Small cuff- overestimates BP
  - Large cuff- underestimates BP
Definitions 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.

- **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).
Pediatric Symptoms

- Hypertension is often thought of as a silent disease because typically there have not been any classic symptoms.

- A study by Croix found that 51% of untreated hypertensive children when surveyed reported 1-4 Symptoms, and 14% reported more than four symptoms.

- 3 most common symptoms:
  - headache
  - difficulty initiating sleep
  - daytime tiredness

These were all reduced with treatment.
Using the BP Tables

1. Use height charts to determine 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).
Using the BP Tables

5. SBP percentiles in the left columns and DBP percentiles in the right columns.

- **Normal BP** = < the 90th percentile
- **Prehypertension** = BP between the 90th and 95th percentile or > 120/80 mmHg in adolescents
- **Hypertension** = BP > than the 95th percentile on repeated measurement
Using the BP Tables

6. BP > the 90th percentile should be repeated twice at the same office visit.

7. BP > the 95th percentile should be staged
   - Stage 1 = 95th percentile to the 99th percentile plus 5 mmHg
   - Stage 2 = >99th percentile plus 5 mmHg
Ambulatory Blood Pressure Monitor (ABPM)

- Small, quiet
- 24 hours
- Many measurements
- Home, school, work
- Awake, asleep
Benefits of ABPM

- No terminal digit preference
- No observer bias
- High reproducibility in adult studies
- It captures the inherent variability of Blood Pressure
- Data!
Average Blood Pressure

Averages for time spent awake

Averages for time spent asleep
Diurnal Blood Pressure Pattern

Dipper or Nondipper
Who is not dipping?

- BP control dissociated from autonomic nerves
  - Diabetes mellitus, autonomic neuropathy, pheochromocytoma
- Increased corticosteroids
  - Cushing’s syndrome, iatrogenic
- BP control dissociated from control organs
  - Chronic renal failure, renal transplant, heart transplant, renal artery stenosis
Leigh Ettinger, MD, MS
Pediatric Nephrology
The Joseph M. Sanzari Children's Hospital
Hackensack University Medical Center
Hackensack, New Jersey 07601

Patient Information
- Gender: Female
- Height: 62 Inches
- Weight: 138 Pounds
- Race: Caucasian
- Physician: Ettinger, Leigh
- Nurse/Technician: Picarelli, Catherine
- Duration: 23:40
- Scan Start: 07/08/14 09:34 Tue
- Scan End: 07/09/14 09:14 Wed
- Successful Reading(s): 56 89%
- Indications: Suspected white-coat hypertension

Overall Summary

<table>
<thead>
<tr>
<th></th>
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<th>STD</th>
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<th>MAX</th>
<th>Dipping</th>
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<tr>
<td>Systolic:</td>
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<td>mmHg</td>
<td>77</td>
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<td>mmHg</td>
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<tr>
<td>MAP:</td>
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<td>9.15</td>
<td>mmHg</td>
<td>55</td>
<td>97</td>
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<td>Pulse Pressure:</td>
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<td>7.21</td>
<td>mmHg</td>
<td>22</td>
<td>63</td>
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<td>Heart Rate:</td>
<td>80</td>
<td>8.18</td>
<td>bpm</td>
<td>67</td>
<td>109</td>
</tr>
</tbody>
</table>

Percent of Systolic above limits: 0%
Percent of Diastolic above limits: 1.8%

Reading(s) | Time
0% | 0%
1.8% | 2.1%

Wake Period(s) 07:00 - 23:00

<table>
<thead>
<tr>
<th></th>
<th>AVG</th>
<th>STD</th>
<th>MIN</th>
<th>MAX</th>
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</thead>
<tbody>
<tr>
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<td>8.81</td>
<td>mmHg</td>
<td>88</td>
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<tr>
<td>Diastolic:</td>
<td>67</td>
<td>7.64</td>
<td>mmHg</td>
<td>49</td>
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<tr>
<td>MAP:</td>
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<td>7.62</td>
<td>mmHg</td>
<td>65</td>
</tr>
<tr>
<td>Pulse Pressure:</td>
<td>39</td>
<td>7.30</td>
<td>mmHg</td>
<td>22</td>
</tr>
<tr>
<td>Heart Rate:</td>
<td>81</td>
<td>8.45</td>
<td>bpm</td>
<td>67</td>
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</table>

Percent of Systolic readings > 128mmHg: 0%
Percent of Diastolic readings > 82mmHg: 0%

Reading(s) | Time
0% | 0%
0% | 0%

Number of Wake Period(s) readings: 42

Sleep Period(s) 23:00 - 07:00

<table>
<thead>
<tr>
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<th>AVG</th>
<th>STD</th>
<th>MIN</th>
<th>MAX</th>
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<tbody>
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<td>mmHg</td>
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<tr>
<td>Diastolic:</td>
<td>54</td>
<td>7.97</td>
<td>mmHg</td>
<td>41</td>
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<td>MAP:</td>
<td>70</td>
<td>8.37</td>
<td>mmHg</td>
<td>55</td>
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<td>Pulse Pressure:</td>
<td>34</td>
<td>5.54</td>
<td>mmHg</td>
<td>28</td>
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<tr>
<td>Heart Rate:</td>
<td>79</td>
<td>7.47</td>
<td>bpm</td>
<td>69</td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 114mmHg: 0%
Percent of Diastolic readings > 66mmHg: 7.1%

Reading(s) | Time
0% | 0%
7.1% | 3.3%

Number of Sleep Period(s) readings: 14

Interpretation
This was a study of good quality with 89% of attempted readings obtained. The 2014 Update on ABPM in Children and Adolescents (AHA) was used to interpret the data. Fiona had a daytime average of 106/67 mmHg, which was normotensive. Her asleep average was also within normal limits. All of her BP loads (percent of time hypertensive) were within acceptable limits. Her diurnal pattern was normal with a 17% dip in average BP while asleep. In sum, this was a normal study that showed that Fiona has normal BPs with no risk factors for end organ damage. There is no need for further intervention now. The 24 hour monitor can be repeated in a few years if office BPs remain high.

Signed

Date

Page 1
Leigh Ettinger, MD, MS
Pediatric Nephrology
The Joseph M. Sanzari Children's Hospital
Hackensack University Medical Center
Hackensack, New Jersey 07601

Name: [redacted]
ID: [redacted]
Date-of-Birth: 12/31/83
Age: 16 Years
Medications: Glucophage Dose: 10.30 Fri
Glucophage 13:00 Thu
Glucophage 20:00 Thu

Patient Information
Gender: Male
Height: 63 Inches
Weight: [redacted]
Race: Caucasian
Physician: Ettinger, Leigh
Nurse/Technician: Picarelli, Catherine
Duration: 23:40
Scan Start: 08/28/14 11:48 Thu
Scan End: 08/29/14 11:28 Fri
Successful Reading(s): 54 86%
Indications: Suspected white-coat hypertension

Overall Summary

<table>
<thead>
<tr>
<th>Systolic</th>
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<th>STD</th>
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<th>MAX</th>
<th>Dipping</th>
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<tbody>
<tr>
<td>123</td>
<td>20.70</td>
<td>mmHg</td>
<td>80 (08:08 Fri)</td>
<td>168 (15:48 Thu)</td>
<td>16.8%</td>
</tr>
<tr>
<td>Diastolic</td>
<td>74</td>
<td>17.89</td>
<td>mmHg</td>
<td>47 (09:48 Fri)</td>
<td>129 (15:48 Thu)</td>
</tr>
<tr>
<td>MAP:</td>
<td>87</td>
<td>17.44</td>
<td>mmHg</td>
<td>52</td>
<td>132</td>
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<td>Pulse Pressure:</td>
<td>49</td>
<td>12.24</td>
<td>mmHg</td>
<td>21</td>
<td>71</td>
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<td>Heart Rate:</td>
<td>84</td>
<td>10.92</td>
<td>bpm</td>
<td>64</td>
<td>110</td>
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Percent of Systolic above limits: 35.2%
Percent of Diastolic above limits: 40.7%

Wake Period(s) 10:00 - 01:00

<table>
<thead>
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<th>MIN</th>
<th>MAX</th>
<th>Dipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>131</td>
<td>19.92</td>
<td>mmHg</td>
<td>95 (10:28 Fri)</td>
<td>168 (15:48 Thu)</td>
<td>16.8%</td>
</tr>
<tr>
<td>Diastolic</td>
<td>84</td>
<td>15.33</td>
<td>mmHg</td>
<td>51 (10:28 Fri)</td>
<td>129 (15:48 Thu)</td>
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<tr>
<td>MAP:</td>
<td>96</td>
<td>15.01</td>
<td>mmHg</td>
<td>64</td>
<td>132</td>
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<tr>
<td>Pulse Pressure:</td>
<td>48</td>
<td>12.57</td>
<td>mmHg</td>
<td>23</td>
<td>70</td>
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<tr>
<td>Heart Rate:</td>
<td>88</td>
<td>10.19</td>
<td>bpm</td>
<td>64</td>
<td>110</td>
</tr>
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Percent of Systolic readings > 133mmHg: 50.0%
Percent of Diastolic readings > 81mmHg: 48.0%
Number of Wake Period(s) readings: 34

Sleep Period(s) 01:00 - 10:00

<table>
<thead>
<tr>
<th>Systolic</th>
<th>AVG</th>
<th>STD</th>
<th>MIN</th>
<th>MAX</th>
<th>Dipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>12.52</td>
<td>mmHg</td>
<td>80 (08:08 Fri)</td>
<td>138 (01:08 Fri)</td>
<td>16.8%</td>
</tr>
<tr>
<td>Diastolic</td>
<td>58</td>
<td>6.56</td>
<td>mmHg</td>
<td>47 (09:48 Fri)</td>
<td>77 (08:31 Fri)</td>
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<tr>
<td>MAP:</td>
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<td>7.80</td>
<td>mmHg</td>
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<tr>
<td>Pulse Pressure:</td>
<td>50</td>
<td>11.74</td>
<td>mmHg</td>
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<td>71</td>
</tr>
<tr>
<td>Heart Rate:</td>
<td>77</td>
<td>8.92</td>
<td>bpm</td>
<td>66</td>
<td>103</td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 118mmHg: 10.0%
Percent of Diastolic readings > 66mmHg: 8.7%
Number of Sleep Period(s) readings: 20

Interpretation
This was a study of good quality with 86% of attempted readings obtained. The 2014 Update on ABPM in Children and Adolescents (AHA) was used to interpret the data. Lucas had a daytime average BP of 131.84 mmHg (nl SBP but high DBP). His asleep BP average was within normal limits. His awake BP loads (percentage of time hypertensive) were elevated. His asleep BP loads were normal. His diurnal pattern was normal with a 16.8% dip in average BP while asleep. In sum, this was an abnormal study that showed that Lucas had daytime DBP hypertension with risk factors for end organ damage.

Signed

Date
## Patient Information
- **Name:** [Redacted]
- **ID:** [Redacted]
- **Date-of-Birth:** [Redacted]
- **Age:** 16 Years
- **Medications:**
- **Dose:**
- **Time:**
- **Gender:** Female
- **Height:** 185 Centimeters
- **Weight:** 125 Kilograms
- **Race:** African-American
- **Physician:** Ettinger, Leigh
- **Nurse/Technician:** Picarelli, Catherine
- **Duration:** 23:19
- **Scan Start:** 04/28/14 16:02 Mon
- **Scan End:** 04/29/14 15:21 Tue
- **Successful Reading(s):** 52 81%
- **Indications:** Suspected white-coat hypertension

## Overall Summary

<table>
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<tr>
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<th>Dipping</th>
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<tr>
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<td>175</td>
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<td>139</td>
<td>212</td>
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<td>Diastolic</td>
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<td>14.32</td>
<td>69</td>
<td>130</td>
<td>17.2%</td>
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<tr>
<td>MAP</td>
<td>120</td>
<td>14.12</td>
<td>93</td>
<td>152</td>
<td>15.0%</td>
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<tr>
<td>Pulse Pressure</td>
<td>75</td>
<td>11.07</td>
<td>53</td>
<td>101</td>
<td></td>
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<tr>
<td>Heart Rate</td>
<td>81</td>
<td>9.05</td>
<td>63</td>
<td>100</td>
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**Percent of Systolic above limits:**
- Reading(s) 100%
- Time 100%
- 88.5%
- 85.6%

**Percent of Diastolic above limits:**
- Reading(s) 100%
- Time 100%
- 97.4%
- 92.6%

### Wake Period(s) 07:00 - 23:00

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<th>Reading(s)</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>182</td>
<td>13.52</td>
<td>147</td>
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<td>100%</td>
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<tr>
<td>Diastolic</td>
<td>105</td>
<td>9.75</td>
<td>80</td>
<td>129</td>
<td>100%</td>
<td>134%</td>
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<tr>
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<td>102</td>
<td>152</td>
<td>100%</td>
<td>152%</td>
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<tr>
<td>Pulse Pressure</td>
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<td>11.59</td>
<td>54</td>
<td>101</td>
<td>100%</td>
<td>101%</td>
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<td>7.90</td>
<td>64</td>
<td>100</td>
<td>100%</td>
<td>100%</td>
</tr>
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</table>

**Percent of Systolic readings > 132mmHg:**
- Reading(s) 100%
- Time 100%
- 97.4%
- 92.6%

**Percent of Diastolic readings > 86mmHg:**
- Reading(s) 100%
- Time 100%
- 97.4%
- 92.6%

**Number of Wake Period(s) readings:** 38

### Sleep Period(s) 23:00 - 07:00

<table>
<thead>
<tr>
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</thead>
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<tr>
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<td>100%</td>
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<td>100%</td>
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<tr>
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<td>14.89</td>
<td>93</td>
<td>144</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
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<td>6.98</td>
<td>53</td>
<td>79</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>74</td>
<td>8.95</td>
<td>63</td>
<td>91</td>
<td>100%</td>
<td>100%</td>
</tr>
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</table>

**Percent of Systolic readings > 119mmHg:**
- Reading(s) 100%
- Time 100%
- 64.3%
- 61.7%

**Percent of Diastolic readings > 78mmHg:**
- Reading(s) 100%
- Time 100%
- 64.3%
- 61.7%

**Number of Sleep Period(s) readings:** 14

### Interpretation
This was a study of good quality with 81% of attempted readings obtained. The 2004 AAP BP guidelines were used to interpret the data. Amarys had severe daytime hypertension with an average daytime BP of 182/105 mmHg. Her asleep BP average was also in the hypertensive range. All of her BP loads (percentage of time spent hypertensive) were elevated. Her diurnal pattern was normal with a 14% dip in average BP while asleep. In sum, this was an abnormal study with severe daytime hypertension with risk factors for end organ damage.

## Signed

**Date**

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Printed: 04/28/14 16:22:58 Wed
Auto Edit Listed Min: 70
Auto Edit Listed Max: 70
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ISBN: 271-909318 DPP: 600 V5.0.3
After Hypertension is Diagnosed

- Want to rule out secondary causes
- BP should be measured in both arms and a leg to rule out coarctation of the aorta
- Fasting lipid, Fasting glucose, standard chemistry panel, serum urea nitrogen (BUN), CBC, creatinine, urinalysis and urine culture
- Echocardiogram, renal ultrasound
- Screen for major sleep disorders using BEARS:
  - Bedtime problems
  - Excessive daytime sleepiness
  - Awakenings during the night
  - Regularity and duration of sleep
  - Snoring
After Hypertension is Diagnosed

- Puberty is a changing point for finding underlying disease. Before puberty 90% of HTN has an underlying cause and 10% is essential. After puberty the ratio inverts to 90% essential and 10% underlying cause. The differential for the underlying cause is extensive. The underlying cause may be treatable with medical or surgical intervention.

- Adult hypertension has to start sometime and there is growing awareness that it is starting in adolescence.
Additional recommendations provided in the Fourth Report:

- Clinical evaluation of confirmed HTN
- Therapeutic lifestyle changes
- Indications for evaluation for secondary hypertension, co-morbidities
- Indications for pharmacological therapy
- Antihypertensive drugs approved for use in hypertensive children
The government’s DASH (dietary approaches to stop hypertension) diet can help, providing menus low in salt and calories and high in nutrients.

- **Nuts, Seeds, Beans**
  All kinds of legumes and nuts—including almonds, filberts, peanuts, sunflower seeds, kidney beans and lentils—are fine. Just hold them to fewer than five servings a week. The size of a serving depends on the food.

- **Meat, Fowl, Fish**
  Up to two servings a day are fine. The key is to keep the portions under control—about 3 oz.—and prepare them well: select lean cuts; trim visible fat; avoid salt; and broil, roast or boil instead of fry. The DASH menus provide tips on spices, seasonings and sauces.

- **Vegetables**
  Up to five servings a day of fruits and another five of vegetables are a big part of the DASH plan. Green leafy plants like bitter greens are a good choice, but so are many more familiar vegetables, including potatoes (baked, not fried).

Menus are available at: [http://nhlbi.nih.gov/health](http://nhlbi.nih.gov/health) (Look under Recipe Collections.)

Photo by AMY REICHMAN / ENVISION
Food Selection to Decrease Caloric and Increase Nutrient Intake

- **GO Foods**—Eat almost anytime.
- **SLOW Foods**—Eat sometimes, at most several times a week.
- **WHOA Foods**—Eat only once in a while or for special treats.

<table>
<thead>
<tr>
<th></th>
<th>GO</th>
<th>SLOW</th>
<th>WHOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable</td>
<td>Plain baked potato</td>
<td>Baked potato with 1 tsp butter and 1 tsp sour cream</td>
<td>French fries</td>
</tr>
<tr>
<td>Bread</td>
<td>Slice of toast</td>
<td>Slice of French toast</td>
<td>Doughnut</td>
</tr>
<tr>
<td>Meat</td>
<td>Skinless chicken breast</td>
<td>Chicken with skin</td>
<td>Fried chicken</td>
</tr>
</tbody>
</table>

Source: Behavioral Risk Factor Surveillance System, CDC.
Exercise: 1 hour per day of Moderate Intensity

The Talk Test

If you are able to Sing = Light Intensity

If you can Talk = Moderate Intensity

If you are Winded = Vigorous Intensity
Wean the Screen

For most Americans, one of the biggest challenges to being more physically active is the amount of time families spend in front of a screen—TV, video games, and computers.

It's time to wean the screen. Setting and agreeing on a certain number of hours each day of "screen time" is important. Health experts recommend that screen time be limited to two hours or less a day that is not work- or homework-related time, such as watching documentary films, doing research, or writing on a computer.

Find out some helpful ways to reduce screen time.
Clinical evaluation of confirmed HTN
Therapeutic lifestyle changes
Indications for evaluation for secondary hypertension, co-morbidities
Indications for pharmacological therapy
Antihypertensive drugs approved for use in hypertensive children
Pharmacologic Therapy

- Indicated when lifestyle modifications are ineffective, when there are symptoms, when there is secondary hypertension, or when there is end organ damage.

- Choice of agent is up to the clinician, with the recommendation that those with proteinuric renal diseases or diabetes mellitus receive an ACE inhibitor or an ARB.
Pharmacologic Therapy

- ACE Inhibitors (angiotensin converting enzyme) i.e. lisinopril, enalapril
- ARB (angiotensin receptor blocker) i.e. Cozaar, Diovan
  - Contraindicated in pregnancy
  - Routine monitoring of K, creatinine
  - Dry cough (seen more with ACE)
Pharmacologic Therapy

- a and b antagonist (labetalol)
- b antagonist (metaprolol, atenolol, propanolol)
  - Asthma, heart failure are relative contraindications.
  - Heart rate is dose-limiting.
  - May impair athletic performance in athletes.
  - Should not be used in insulin-dependent DM
Pharmacologic Therapy

- Calcium Channel Blockers (amlodipine)
  - May cause tachycardia
  - May cause edema
- Diuretics
  - All patients treated with diuretics should have electrolytes monitored periodically
  - Most useful as add-on therapy in patients being treated with drugs from other drug classes
AAP guidelines 2008
Medical Conditions Affecting Sports Participation

Sports Participation with Hypertension

“A Qualified Yes”
Those with hypertension >5 mmHg above the 99th percentile for age, gender, and height (ie Stage 2 Hypertension) should avoid heavy weightlifting and power lifting, bodybuilding, and high-static component sports.
Athletic Participation by Children and Adolescents Who have Systemic Hypertension (AAP, June, 2010)

- Asymptomatic Athletes with Pre-HTN and Essential HTN should be encouraged to play.
- Athletes with Stage 2 hypertension and/or symptoms and/or LVH should be restricted from high-static activities until their BP is controlled with medicine, and then play.
I hope that this is not too burdensome... but, if you think it is, you are not alone.

“The sphygmomanometer would not be welcomed by the overworked and underpaid general practitioner already loaded with thermometer, stethoscope, etc.”

Blake E., Recent British researches on arterial tension. Med Times Gaz, 1895;23:29.
Conclusion

- Hypertension and obesity in children are increasing in an upward trend.
- It is imperative that pediatric hypertension is recognized and treated.
- It is important to encourage healthy lifestyles in all children and adolescents and help institute lifestyle changes for weight reduction in overweight children.
Resources
