

# Pediatric Hypertension

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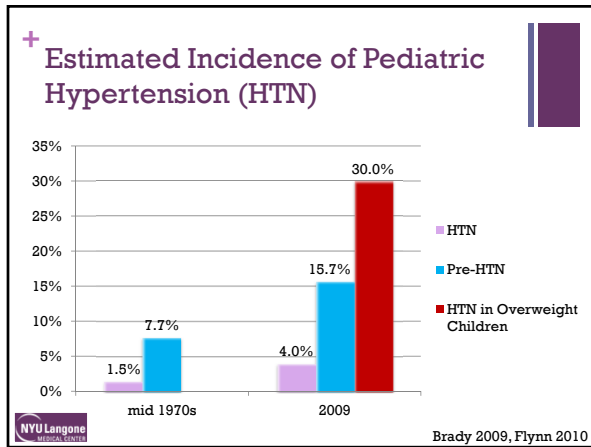
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## Definitions

	Pediatrics	Adults
Normal BP	SBP or DBP <90 <sup>th</sup> percentile for age	SBP <120 DBP <80
Pre-hypertension	SBP or DBP 90-95 <sup>th</sup> percentile for age OR BP>120/80	SBP 120-139 DBP 80-89
Stage 1 Hypertension	SBP or DBP 95-99 <sup>th</sup> percentile for age +5 mmHg	SBP 140-159 DBP 90-99
Stage 2 Hypertension	SBP or DBP >99 <sup>th</sup> percentile for age +5 mmHg	SBP ≥160 DBP ≥100

Classifications based off of the average of 2 or more readings taken at each of 2 or more visits following initial screening

Portman 2005, Chobanian 2003



## Methods of BP Evaluation

- Auscultatory measurements**- sphygmomanometer and stethoscope
  - Basis for BP tables
  - Patient should sit quietly for 5 minutes with his or her back supported, feet on the floor and right arm supported at heart level
  - Cuff size should be at least 2/3 distance from acromion to olecranon
- Oscillometric (Dinamapp) measurements**- automatic device that measures mean arterial BP and then calculates systolic and diastolic values
  - Measurements generally comparable to auscultatory
  - Oscillometric devices are convenient, have minimal observer error
- Ambulatory BP monitoring (ABPM)**- portable device worn by the patient to record BP over a specific period (usually 24 hours)
  - Enables calculation of:
    - mean daily BP during the day, night and over 24 hours
    - degree of nocturnal dipping
    - BP load (%readings >95%)
  - Useful to evaluate white-coat and masked HTN
  - Correlates better than office BP with CV complications (e.g. LVH)

NHBPEP 2004

## Chart of Office versus ABPM

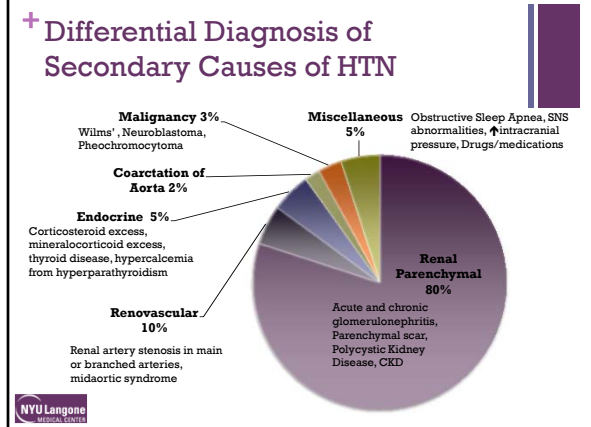
		Office BP Measurement			
		Normal		High	
Ambulatory BP Measurement	Normal	Normal BP	80%	White-coat HTN	10%
	High	Masked HTN	45%	Sustained HTN	20%
			7%		3%
			10%		25%

Blue= patients at healthy checkups  
Green= patients referred for elevated BP

## Causes of Pediatric Hypertension

- Primary or Essential Hypertension**
  - Most common form of HTN and is a diagnosis of exclusion
  - Common at all ages
  - More frequent in:
    - African American children
    - Family history of HTN
    - Overweight or obese
- Secondary Hypertension**
  - For all age groups, renal parenchymal or renovascular causes together account for ~80-90% of secondary causes
  - More frequent in:
    - Younger children
    - Children with a greater degree of BP increase at the time of initial diagnosis

Portman 2005, Brady 2009



### + Common Causes of HTN by Age

Infants	Children		Adolescents
	1-6 y	7-12 y	
Thrombosis of renal artery or vein	Renal artery stenosis	Renal parenchymal disease	Essential HTN
Congenital renal anomalies	Renal parenchymal disease	Renovascular abnormalities	Renal parenchymal disease
Coarctation of Aorta	Wilms tumor	Endocrine causes	Endocrine causes
Bronchopulmonary dysplasia	Neuroblastoma	Essential HTN	
	Coarctation of aorta		

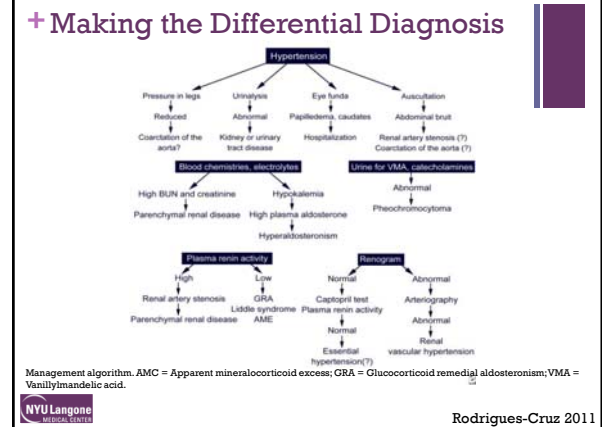
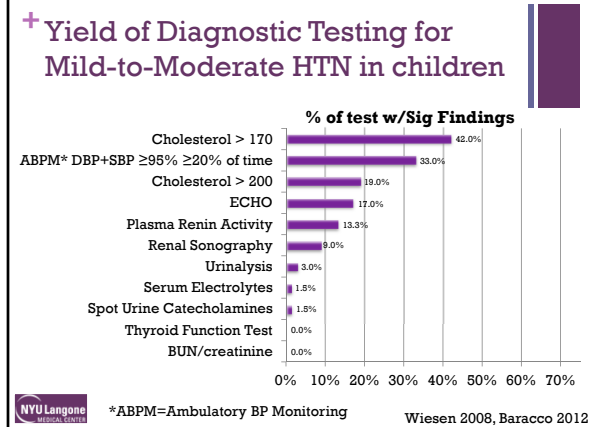
**NYU Langone Medical Center** Rodrigues-Cruz 2011

- ### + Clinical and Laboratory Assessment of Children with HTN
- Important History Elements:
    - Symptoms suggestive of endocrine etiology (weight loss, sweating, flushing etc.)
    - History of prematurity and/or placement of umbilical artery/vein catheter; neonatal course; birth weight (all hypothesized to predict HTN)
    - History of UTI
    - Symptoms of Obstructive Sleep Apnea
    - Medications including steroids, decongestant/cold prep, OCP, NSAIDs, stimulants, βadrenergic agonists, EPO, cyclosporine/tacrolimus, tricyclic anti-depressants, recent discontinuation of antihypertensive
    - Nutritional Supplements
    - Family history of HTN, early cardiovascular or cerebrovascular events, ESRD
    - Diet (caffeine, salt intake)
    - Smoking/drinking/illicit drugs
    - Physical Activity
- NYU Langone Medical Center** Brady 2009

- ### + Clinical and Laboratory Assessment of Children with HTN
- Important Physical Exam Elements
    - Four extremity pulses and BP
    - Moon facies, truncal obesity, buffalo hump
    - Retinopathy
    - Thyromegaly
    - Skin lesions (café-au-lait spots, neurofibromas, adenoma sebaceum, striae, hirsutism, butterfly rash, purpura)
    - Evidence of CHF
    - Abdominal mass, abdominal bruits
    - Edema
- NYU Langone Medical Center** Brady 2009

- ### + Clinical and Laboratory Assessment of Children with HTN
- Laboratory Evaluation:
    - Specific tests may vary by clinic location and patient population
    - To rule out renal disease and chronic pyelonephritis:
      - Basic metabolic panel (electrolytes, BUN, HCO<sub>3</sub>, creatinine)
      - Urinalysis
      - Urine Culture
    - CBC to rule out anemia which could be consistent with CKD
    - Fasting lipids and glucose
    - Thyroid function tests
    - Plasma renin activity: very young with Stage 1 and children with Stage 2
- NYU Langone Medical Center** Brady 2009

- ### + Clinical and Laboratory Assessment of Children with HTN
- Imaging:
    - Renal ultrasound with Doppler examination of the renal vasculature
    - Echocardiography including measurement of LVMI
    - Renal arteriography: severe HTN or failure to control BP with one drug
  - Other Tests:
    - Retinal Exam: severe cases
    - Assessment of catecholamines: United States NO versus Europe YES
- NYU Langone Medical Center** Brady 2009



### + General Therapeutic Recommendations for Pediatric HTN

TABLE 3. Classification of hypertension in children and adolescents, with measurement frequency and therapy recommendations.

Category	SBP or DBP percentile*	Frequency of BP measurement	Therapeutic lifestyle changes	Pharmacologic therapy
Normal	<90th	Recheck at next scheduled physical examination	Encourage healthy diet, sleep, and exercise	---
Prehypertension	90th to <95th or if BP exceeds 120/80 even if below 90th percentile up to <135th percentile†	Recheck in 6 months	Weight management counseling if overweight, encourage exercise and diet management	None unless compelling indications such as CAD, diabetes mellitus, heart failure, LVH
Stage 1 hypertension	95th percentile to the 99th percentile plus 5 mmHg	Recheck in 1-2 weeks; if persistently elevated on two additional occasions, evaluate or refer to source of care within 1 month or sooner if the patient is symptomatic	Weight management counseling if overweight, introduce exercise and diet management	Initiate therapy based on indications in Table 12 or if compelling indications as above
Stage 2 hypertension	>99th percentile plus 5 mmHg	Evaluate or refer to source of care within 1 week or immediately if the patient is symptomatic	Weight management counseling if overweight, encourage exercise and diet management	Initiate therapy‡

BP, blood pressure; CAD, chronic kidney disease; DBP, diastolic blood pressure; LVH, left ventricular hypertrophy; SBP, systolic blood pressure.  
\*10th, 90th, and 95th percentiles measured on at least three separate occasions; if systolic and diastolic categories are different, categorize by the higher value.  
†This occurs typically at 12 years old for SBP and at 16 years old for DBP.  
‡Frequency: More than one medication is required.

NYU Langone Medical Center | Portman 2005

- ### + Practice Guidelines for Pediatric BP Monitoring
- All healthy children ≥3 years of age and children younger than 3 with certain comorbid conditions (e.g. prematurity, low birth weight, kidney disease, congenital heart disease) should have their BP measured at all physician visits
  - If either SBP or DBP is elevated (≥90<sup>th</sup> percentile or SBP ≥120mmHg or DBP ≥80mmHg if these values are lower than the 90<sup>th</sup> percentile), the BP should be measured 2 additional times on 2 separate visits
  - ABPM can expedite determination of BP status
- NYU Langone Medical Center | Brady 2009

- ### + Non-pharmacological Interventions
- Table 3. Nonpharmacologic interventions**
- Aerobic exercise:** 30-45 minutes most days of the week
  - Limit sedentary activities** to less than 2 hours/day
  - Weight reduction if overweight:** Increased intake of fresh vegetables, fruits, and low-fat dairy (the Dietary Approaches to Stop Hypertension [DASH] Study eating plan)<sup>15</sup>
  - Salt restriction\*** Adequate intake of potassium and calcium (both shown to have antihypertensive effects)<sup>16</sup>
  - Cessation of smoking**
- Data from the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.<sup>11</sup>  
\*Can start with recommending no added salt, with the ultimate goal of achieving the current recommendation of 1.2 grams/day total for 4- to 8-year-olds and 1.5 grams/day total for children 9 years of age and older.<sup>11</sup>
- Suggested for all patients with prehypertension and hypertension
  - Most patients with pediatric primary HTN should have a trial of non-pharmacologic management prior to starting drug treatment
  - Loss of 10-15 lbs (4-7 kg) is sufficient to achieve a meaningful reduction in BP
  - Physical activity with increased HR for 30-40 minutes, 3-4x/wk can lead to a demonstrable drop in BP
- NYU Langone Medical Center | Brady 2009, Trachtman 2011

- ### + Pharmacological Intervention: Who Should Get Drugs?
- The 2004 NHBPEP guidelines indicate pharmacological therapy in children with one or more of the following conditions:
    - Symptomatic HTN (e.g. headache, seizures, changes in mental status, focal neurological complaints, visual disturbances, CV complaints)
    - Stage 2 HTN
    - Stage 1 HTN (without any evidence of target-organ damage) that persists despite a trial of 4-6 months of non-pharmacologic therapy
    - Hypertensive target-organ damage, most often LVH
    - Stage 1 HTN with diabetes mellitus or other CVD risk factors such as dyslipidemia
    - Stage 1 HTN with family history of premature CVD
    - Prehypertension in presence of comorbid conditions, such as chronic kidney disease or diabetes mellitus
- NYU Langone Medical Center | NHBPEP 2004

### + Stage 2 Acute HTN Crisis Treatment Principles

- Blood pressure above the 99<sup>th</sup> percentile or more than 4 SDs above the mean is considered severe, however any BP in the presence of neurological symptoms is an acute emergency and requires urgent attention
- Target of treatment is not to normalize the BP but to lower the mean arterial pressure by 20% so that a regular regimen can be started
- Children are less likely to have atherosclerosis and therefore can tolerate sudden drops in BP without the risk of vital organ ischemia, MI or stroke



Trachtman 2011

### + Stage 2 Acute HTN Crisis Pharmacologic Therapy

Line	Drug	Route	Category	Dosage
1 <sup>st</sup> Line	Labetalol	IV	$\alpha/\beta$ Blocker	0.25-1 mg/kg per dose administered by rapid transfusion
2 <sup>nd</sup> Line	Isradipine	IV	CCB	0.1 dose mg/kg per dose
	Nicardipine	IV	CCB	0.1-0.3 dose $\mu$ g/kg per minute
3 <sup>rd</sup> Line	Enalaprilat	IV	ACEI	0.005-0.1 mg/kg per hour
4 <sup>th</sup> Line	Enalapril	PO	ACEI	0.1-0.5 mg/kg per day, 1-2x per day
	Clonidine	PO	Central acting	5-25 $\mu$ g/kg per day, 2-3x per day
	Minoxidil	PO	Vasodilator	0.25-1 mg/kg per day divided BID
	Nifedipine	PO	CCB	0.25-0.5 mg/kg per dose, 3-4 x per day



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### + Stage 1 Chronic HTN Treatment Principles

- Choice of medication should be guided by underlying condition and the presence of other comorbidities
- Patients with HTN and migraine headaches should receive  $\beta$ blockers or CCBs, while children with diabetes and HTN should receive ACEI or angiotensin II receptor blockers (ARBs)
- Because of their metabolic effects, such as lowering TGF- $\beta$  and Angiotensin II, ACEI and ARBs are indicated for patients with end-organ damage such as cardiac hypertrophy
- Prescribe drugs that do not cause adverse effects on QOL in order to prevent non-adherence to drug regimen
- It is advisable to use the fewest of agents possible and to prescribe once-daily dosing regimens



Trachtman 2011, Portman 2005

### + Stage 1 Chronic Primary HTN Pharmacologic Therapy

- Drug therapy is warranted if non-pharmacologic options fail to be effective or if the child is symptomatic, has other cardiovascular (CV) risk factors, family history of premature CVD, diabetes mellitus, or target-organ damage
- Diuretics alone will work in 50% of pediatric patients with HTN while additional drugs will be needed to control the other half

Table 2 Drugs for use in chronic hypertension

Drug	Class	Dose	Side effects
Chlorthalidone	Diuretic	0.3-2 mg/kg per day Maximum 50 mg Given every 24 hours	Hypokalemia, hypoglycemia, hyperurcemia, renal injury
Enalapril	ACEI	0.1-0.4 mg/kg per day Maximum 40 mg Given every 12-24 hours	Cough, hyperkalemia, angioedema, decreased GFR
Losartan	ARB	0.7-1.4 mg/kg per day Maximum 100-150 mg Given every 12-24 hours	Hyperkalemia, decreased GFR
Amlodipine	CCB	0.05-0.3 mg/kg per day Maximum 15-20 mg Given every 12-24 hours	Flushing, edema, headache

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II type 1 receptor blocker; CCB, calcium channel blocker; GFR, glomerular filtration rate.



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### + Stage 1 Chronic Secondary HTN Pharmacologic Therapy

- All patients with secondary HTN should be started on anti-hypertensive medication
- The underlying cause of HTN should be treated if possible
- Child with HTN caused by renal disease should be prescribed drugs that block the synthesis/action of angiotensin II and aldosterone due to their renoprotective effects. These include:
  - **ACEI**, e.g., enalapril, lisinopril, ramipril and fosinopril
    - Note: Patients may experience a marked decline in kidney function when they start ACEI
  - **ARBs**, e.g., losartan, valsartan, irbesartan
  - Recently developed **renin inhibitors**, aliskiren
  - **Aldosterone antagonists**, e.g., spironolactone, eplerenone



Brady 2009, Trachtman 2011

### + General Schematic of Work-Up and Treatment of Pediatric HTN

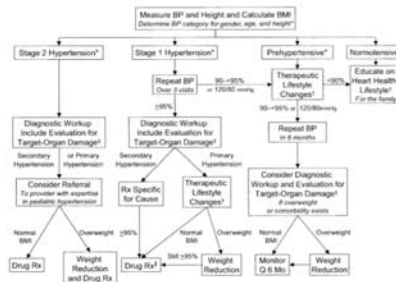


Fig 1. Management algorithm. Rx indicates prescription; Q, every. \* See Tables 3, 4, and 5; † diet modification and physical activity; ‡ especially if younger, very high BP, little or no family history, diabetic, or other risk factors.



NHBPEP 2004

## + Prognosis

- There is very little data available on the natural history of primary HTN in children so it is impossible to predict the long-term outcomes of untreated HTN in children and adolescents
- One small study in Iceland demonstrated a correlation between childhood SBP and the development of coronary artery disease in adulthood
- LVH occurs in ~33% of children and adolescents with mild, untreated HTN
- Preventing end organ damage including vascular changes, cardiac damage and renal effects should be the goal of treatment for pediatric hypertensive patients



Flynn 2010, NHBPEP 2004

## + References



- Baracco R, et al. Prediction of primary vs secondary hypertension in children. *Off J of Am Soc of HTN* 2012; 14:316-321.
- Brady TM, Feld LG. Pediatric approach to hypertension. *Semin Nephrol* 2009; 29:375-388.
- Chobanian AV, et al. NHBPEP Coordinating Committee. 7<sup>th</sup> report of the Joint National Committee on prevention, detection, evaluation and treatment of high blood pressure. *Hypertension* 2003; 42:1206-1252.
- Flynn JT. Pediatric hypertension update. *Curr Opin Neph Hyperten* 2010; 19:230-237.
- Luzbe E, et al. Prevalence, persistence, and clinical significance of masked hypertension in youth. *Hypertension* 2005; 45: 493-498.
- NHBPEP Working Group on High BP in Children and Adolescents. The 4<sup>th</sup> report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004; 114:555-574.
- Portman RJ, et al. Pediatric hypertension: diagnosis, evaluation, management, and treatment for primary care physicians. *Curr Probl Pediatr Adolesc Health Care* 2005; 4:282-294.
- Rodriguez-Cruz E. (2011, December 9). Pediatric hypertension. Retrieved July 2012. <http://emedicine.medscape.com/article/889877-overview>
- Stabouli S, et al. White-coat and masked hypertension in children: association with target-organ damage. *Pediatr Nephrol* 2005; 20: 1151-1155.
- Stergion, et al. White-coat hypertension and masked hypertension in children. *Blood Press Monit* 2005; 10: 297-300.
- Trachtman H. Short- and long-term physiologic and pharmacologic control of blood pressure in pediatric patients. *Integ Blood Press Contr* 2011; 4:35-44.
- Urbina E, et al. Ambulatory BP monitoring in children and adolescents: recommendations for standard assessment. *Hypertension* 2008; 52: 433-451.
- Wisson J, et al. Evaluation of pediatric patients with mild-to-moderate hypertension: yield of diagnostic testing. *Pediatric* 2009; 122:e988-e993.