# Paediatric Hypertension- Reviewing the new guidelines

Dr Sandrica Young Peart

# Objectives

- To define HTN, HTN urgency and emergency
- To review the new guidelines for HTN in children
- To review the challenges in diagnosing neonatal HTN
- To review the causes of neonatal HTN
- To review the causes of secondary HTN in children and adolescents
- To evaluate the child with HTN
- To review indications for treatment
- To review the management of HTN and its gency

# Case presentation

- J.T. is 14 yr old boy, referred at July 2018 for HTN (from 132 to 160 mm systolic,  90 diastolic).
- Asymptomatic. No headache, No dysuria or urination problems.
- No UTIs, No illicit drug use
- No personal or family history of renal diseases or HTN.

## *Clinical examination*

- Height 179 cm, weight 71.8 kg, manual BP 140/90
- Normal physical examination

## *Laboratory investigations*

- Urinalysis: sp grav -1.010; blood, leukocyte esterase and glucose negative, protein-neg.
- U protein/creatinine 0.010 g/mmol (normal)
- Serum creatinine 77 µM (CKiD eGFR 127 mL/min/1.73 $m^2$)
- Normal serum electrolytes, thyroid, uric acid and aldosterone

# ABPM 24 BP monitoring

- Average BP was 141/87, load 65/78%.
- 95% of BP is 137/85.
- Night BP- 131/83- elevated.

# Abdominal US

FINDINGS:

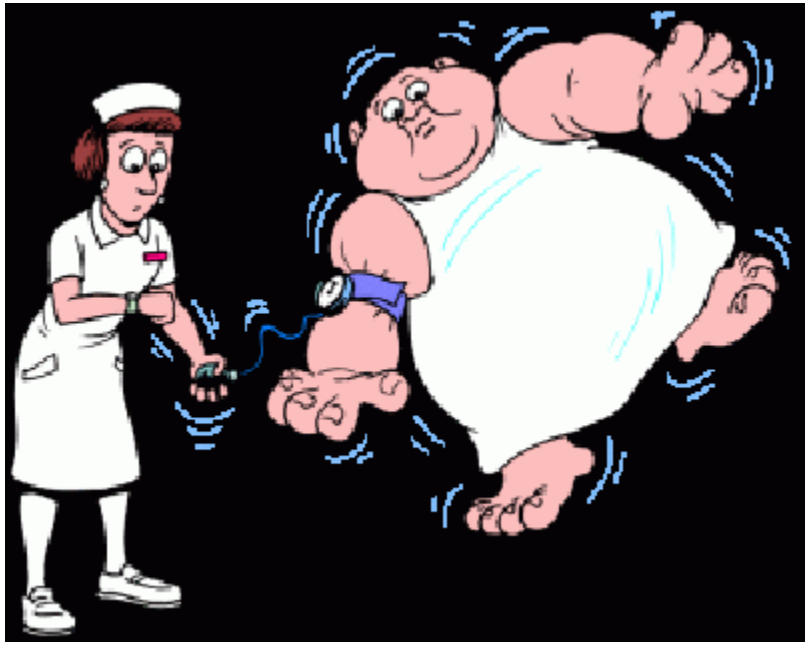
- R kidney-10.4 cm. L. kidney-11 cm,
- bilateral several scars along the renal cortex
- loss of corticomedullary differentiation
- mild dilatation of the collecting system on the left particularly the upper pole.
- Doppler-normal

# Why is it important to diagnose and treat hypertension in childhood?

- Prevent progression and target organ damage of the brain, eyes, heart, and kidneys
- A study by Hanevoid demonstrated that severe target organ damage occurs in hypertensive children
  - 41% of the 129 hypertensive children and adolescents studied had left ventricular hypertrophy (LVH) by pediatric criteria, and 16% had LVH even when using adult criteria
- If caught early, preventative measures can be taken to reduce risks for other comorbidities in childhood and adulthood

# Definition of Hypertension

- Systolic or diastolic BP ≥ to the 95$^{th}$ % for age, gender and height or BP greater than 120/80 on three separate occasions
- Appropriate BP cuff
- Bladder should encircle the arm 80-100%
- 2-3 cm above the ante-cubital fossa
- Wrist and forearm BPs should not be used



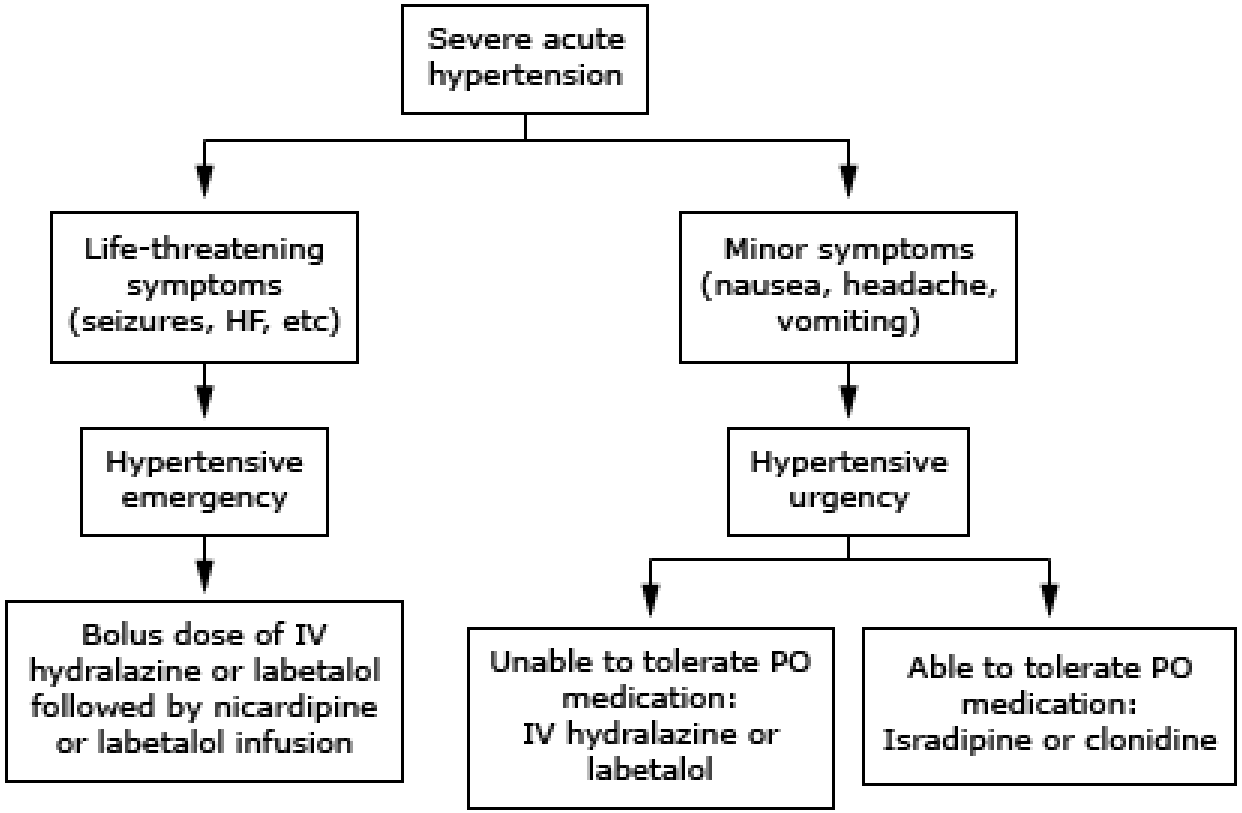
# HTN Emergency and Urgency

- Emergency
  - A severe symptomatic elevation in BP **with** evidence of potentially life threatening symptoms or acute target organ damage
    - Seizures, heart failure, papilledema, renal insufficiency
    - absolute degree of BP elevation is less important than whether end organ symptoms and/or damage is present
    - BP lowered no more than 25% over first 8 hrs

- Urgency
  - A severe elevation in BP **without** severe symptoms or evidence of acute target organ damage
  - Acute process requires prompt intervention with IV meds

# HYPERTENSION

# Initial management of children with severe hypertension




HF: heart failure; IV: intravenous; PO: oral.

*Reproduced with permission from: Flynn, JT, Tullus, K. Severe hypertension in children and adolescents: pathophysiology and treatment. Pediatr Nephrol 2008; Online first. Copyright © 2008 Springer Science and Business Media.*

**Intravenous drugs for treatment of hypertensive emergencies and urgencies in children**

| Drug* | Route | Dose range¶ | Onset of action | Duration of action | Mechanism of action | Comments Δ |
|---|---|---|---|---|---|---|
| **Labetalol** | Intravenous infusion or bolus | Bolus: 0.2- 1 mg/kg per dose up to maximum 40 mg/dose<br>Infusion: 0.25-3 mg/kg per hour | 2-5 min | 2-6 hr | α- and β - adrenergic blocker | Relatively contraindicated in asthma, BPD, HF and may mask symptoms of hypoglycemia |
| **Nicardipine** | Intravenous infusion | Bolus: 30 mcg/kg up to maximum 2 mg per dose<br>Infusion: 0.5-4 mcg/kg per minute | 2-5 min | 30 min - 4 hr (increases with time of infusion) | Calcium channel blocker | May cause reflex tachycardia |
| Hydralazine | Intravenous bolus | IV: 0.1-0.2 mg/kg per dose up to 0.4 mg/kg per dose<br>Maximum single dose: 20 mg | 10 min (max effect may take up to 80 min) | 4-6 hours | Direct vasodilator | May cause reflex tachycardia<br>Variable response with potential for prolonged hypotension |
| Esmolol | Intravenous infusion | 100-500 mcg/kg loading dose then 100-500 mcg/kg per minute | Immediate | 10-30 min | β - adrenergic blocker | Relatively contraindicated in asthma, BPD, HF and may cause profound bradycardia |
| Fenoldopam | Intravenous infusion | 0.2 mcg/kg/minute per minute up to 0.8 mcg/kg per minute | 5-40 min | 60 min | Peripheral dopamine receptor agonist | Limited experience in children |
| Nitroprusside | Intravenous infusion | 0.5-3 mcg/kg/minute starting dose<br>Maximum dose 10 mcg/kg/minute | Seconds | Effect requires continuous infusion | Venodilator with some arteriolar dilation | Monitor cyanide levels with prolonged (>72 hr) use or in renal failure; or coadminister sodium thiosulfate<br>May increase ICP |

ICP: intracranial pressure; BPD: bronchopulmonary dysplasia; HF: heart failure.
* Bolded medications are preferred for hypertensive emergencies in children.
¶ For more specific drug information, refer to Lexicomp drug database.
Δ All agents may cause excessive hypotension.

*Adapted from: Flynn, JT, Tullus, K. Severe hypertension in children and adolescents: pathophysiology and treatment. Pediatr Nephrol 2009; 24:1101.*

UpToDate®

# Neonatal BP

- Incidence ~ 1%
- Challenge in establishing norms
- Can be measured with a Doppler
- Correlation with Doppler and oscillometric measurements
- Should not be done close to investigations or feeds
- BPs are significantly higher when sucking on pacifier, crying, being tilted or held up
- Asymptomatic or present with lethargy, seizures, coma, tachypnea, ICH, apnea, FTT, abdominal distension, polyuria, fever, cardiomegaly

Dionne, J., Flynn, J., Hypertension in the neonate

## Causes of neonatal hypertension

- **Renovascular**
  - Thromboembolism
  - Renal artery stenosis
  - Mid-aortic coarctation
  - Renal venous thrombosis
  - Renal artery compression
  - Idiopathic arterial calcification
  - Congenital rubella syndrome
- **Renal parenchymal disease**
  - **Congenital**
    - Polycystic kidney disease
    - Multicystic-dysplastic kidney disease
    - Tuberous sclerosis
    - Ureteropelvic junction obstruction
    - Unilateral renal hypoplasia
    - Congenital nephrotic syndrome
    - Renal tubular dysgensis
  - **Acquired**
    - Acute tubular necrosis
    - Cortical necrosis
    - Interstitial nephritis
    - Hemolytic uremic syndrome
    - Obstruction (stones, tumors)
- **Pulmonary**
  - Bronchopulmonary dysplasia
  - Pneumothorax
- **Cardiac**
  - Thoracic aortic coarctation
- **Endocrine**
  - Congenital adrenal hyperplasia
  - Hyperaldosteronism
  - Hyperthyroidism
  - Pseudohypoaldosteronism type II
  - **Infant**
    - Dexamethasone
    - Adrenergic agents
    - Vitamin D intoxication
    - Theophylline
    - Caffeine
    - Pancuronium
    - Phenylephrine
  - **Maternal**
    - Cocaine
    - Heroin
- **Neoplasia**
  - Wilms tumor
  - Mesoblastic nephroma
  - Neuroblastoma
  - Pheochromocytoma
- **Neurologic**
  - Pain
  - Intracranial hypertension
  - Seizures
  - Familial dysautonomia
  - Subdural hematoma
- **Miscellaneous**
  - Total parenteral nutrition
  - Closure of abdominal wall defect
  - Adrenal hemorrhage
  - Hypercalcemia
  - Traction
  - Extracorporeal membrane oxygenation
  - Birth asphyxia
  - Nephrocalcinosis

| Post-conceptual 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** | **77** |
| **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** | **49** | **64** | **69** |
| **30 weeks** | | | |
| SBP | 65 | 80 | 85 |
| DBP | 40 | 55 | 60 |
| **MAP** | **48** | **63** | **68** |
| **28 weeks** | | | |
| SBP | 60 | 75 | 80 |
| DBP | 38 | 50 | 54 |
| **MAP** | **45** | **58** | **63** |
| **26 weeks** | | | |
| SBP | 55 | 72 | 77 |
| DBP | 30 | 50 | 56 |
| **MAP** | **38** | **57** | **63** |

This table provides estimated values for blood pressures after two weeks of age in infants from 26 to 44 weeks post-conceptual age. The 95th and 99th percentile values are intended to serve as a reference to identify infants with persistent hypertension that may require treatment.

SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure.

# Definition of hypertension

## Guidelines published by the Working Group

| Blood pressure | SBP or DBP Percentile* |
|---|---|
| Normal | <90th |
| Pre-hypertension | 90th to <95th or if BP exceeds 120/80 mmHg |
| Stage 1 hypertension | 95th percentile to the 99th percentile plus 5 mmHg |
| Stage 2 hypertension | >99th percentile plus 5 mmHg |

*Blood pressure percentiles are age, gender and height specific.

**Pediatrics (2004) Vol. 114 No.2** The 4th report on the diagnosis, evaluation & treatment of high blood pressure in children and adolescents.

## 2017 American Academy of Pediatrics updated definitions for pediatric blood pressure categories

| | For children aged 1 to 13 years | For children aged ≥13 years |
|---|---|---|
| **Normal BP** | Systolic and diastolic BP <90$^{th}$ percentile | Systolic BP <120 and diastolic BP <80 mmHg |
| **Elevated BP** | Systolic and diastolic BP ≥90$^{th}$ percentile to <95$^{th}$ percentile, or 120/80 mmHg to <95$^{th}$ percentile (whichever is lower) | Systolic BP 120 to 129 and diastolic BP <80 mmHg |
| **Stage 1 HTN** | Systolic and diastolic BP ≥95$^{th}$ percentile to <95$^{th}$ percentile + 12 mmHg, or 130/80 to 139/89 mmHg (whichever is lower) | 130/80 to 139/89 mmHg |
| **Stage 2 HTN** | Systolic and diastolic BP ≥95$^{th}$ percentile + 12 mmHg, or ≥140/90 mmHg (whichever is lower) | ≥140/90 mmHg |

BP: blood pressure; HTN: hypertension.

## Causes of secondary hypertension in children and adolescents

| Renal disease |
| --- |
| Pyelonephritis |
| Renal parenchymal disease |
| Congenital anomalies |
| Reflux nephropathy |
| Acute glomerulonephritis |
| Henoch-Schönlein purpura |
| Renal trauma |
| Hydronephrosis |
| Hemolytic uremic syndrome |
| Renal stones |
| Nephrotic syndrome |
| Wilm's tumor |
| Hypoplastic kidney |
| Polycystic kidney disease |

| Psychologic causes |
| --- |
| Mental stress |
| Anxiety |
| **Pharmacologic causes** |
| Sympathomimetics |
| Corticosteroids |
| Stimulants |
| Oral contraceptives |
| Anabolic steroids |
| Cocaine |
| Phencyclidine (PCP) |
| Licorice |
| Nicotine |
| Caffeine |

| Endocrine disease |
| --- |
| Hyperthyroidism |
| Congenital adrenal hyperplasia |
| Cushing syndrome |
| Primary aldosteronism |
| Primary hyperparathyroidism |
| Diabetes mellitus |
| Hypercalcemia |
| Pheochromocytoma |
| **Neurologic causes** |
| Increased intracranial pressure |
| Guillain-Barré syndrome |

| Vascular disease |
| --- |
| Renal artery abnormalities |
| Renal vein thrombosis |
| Coarctation of the aorta |
| Patent ductus arteriosus |
| Arteriovenous fistula |
| **Other causes** |
| Neuroblastoma |
| Heavy metal poisoning |
| Acute pain |
| Collagen vascular diseases |
| Neurofibromatosis |
| Tuberous sclerosis |

*Data from:*

1. *Tunnessen WW, Roberts KB. Hypertension. In: Signs and Symptoms in Pediatrics, 3rd ed, Lippincott, Williams & Wilkins, Philadelphia 1999. p.413.*
2. *Pappadis SL, Somers MJ. Hypertension in adolescents: a review of diagnosis and management. Curr Opin Pediatr 2003; 15:370.*

**TABLE 14** Examples of Physical Examination Findings and History Suggestive of Secondary HTN or Related to End Organ Damage Secondary to HTN

| Body System | Finding, History | Possible Etiology |
|---|---|---|
| Vital signs | Tachycardia | Hyperthyroidism |
| | | PCC |
| | | Neuroblastoma |
| | Decreased lower extremity pulses; drop in BP from upper to lower extremities | Coarctation of the aorta |
| Eyes | Proptosis | Hyperthyroidism |
| | Retinal changes[a] | Severe HTN, more likely to be associated with secondary HTN |
| Ear, nose, throat | Adenotonsillar hypertrophy | SDB |
| | History of snoring | Sleep apnea |
| Height, weight | Growth retardation | Chronic renal failure |
| | Obesity (high BMI) | Cushing syndrome |
| | Truncal obesity | Insulin resistance syndrome |
| Head, neck | Elfin facies | Williams syndrome |
| | Moon facies | Cushing syndrome |
| | Thyromegaly, goiter | Hyperthyroidism |
| | Webbed neck | Turner syndrome |
| Skin | Pallor, flushing, diaphoresis | PCC |
| | Acne, hirsutism, striae | Cushing syndrome |
| | | Anabolic steroid abuse |
| | Café-au-lait spots | Neurofibromatosis |
| | Adenoma sebaceum | Tuberous sclerosis |
| | Malar rash | Systemic lupus |
| | Acanthosis nigricans | T2DM |

| | | |
|---|---|---|
| Hematologic | Pallor | Renal disease |
| | Sickle cell anemia | |
| Chest, cardiac | Chest pain | Heart disease |
| | Palpitations | |
| | Exertional dyspnea | |
| | Widely spaced nipples | Turner syndrome |
| | Heart murmur | Coarctation of the aorta |
| | Friction rub | Systemic lupus (pericarditis) |
| | | Collagen vascular disease |
| | Apical heave[a] | LVH |
| Abdomen | Abdominal mass | Wilms tumor |
| | | Neuroblastoma |
| | | PCC |
| | Epigastric, flank bruit | RAS |
| | Palpable kidneys | Polycystic kidney disease |
| | | Hydronephrosis |
| | | Multicystic dysplastic kidney |
| Genitourinary | Ambiguous or virilized genitalia | Congenital adrenal hyperplasia |
| | Urinary tract infection | Renal disease |
| | Vesicoureteral reflux | |
| | Hematuria, edema, fatigue | |
| | Abdominal trauma | |
| Extremities | Joint swelling | Systemic lupus |
| | | Collagen vascular disease |
| | Muscle weakness | Hyperaldosteronism |
| | | Liddle syndrome |
| Neurologic, metabolic | Hypokalemia, headache, dizziness, polyuria, nocturia | Reninoma |
| | Muscle weakness, hypokalemia | Monogenic HTN (Liddle syndrome |

Screening Tests and Relevant Populations

| Patient Population | Screening Tests |
|---|---|
| All patients | Urinalysis |
| | Chemistry panel, including electrolytes, blood urea nitrogen, and creatinine |
| | Lipid profile (fasting or nonfasting to include high-density lipoproteins and total cholesterol) |
| | Renal ultrasonography in those <6 y of age or those with abnormal urinalysis or renal function |
| In the obese (BMI >95th percentile) child or adolescent, in addition to the above | Hemoglobin A1c (accepted screen for diabetes) |
| | Aspartate transaminase and alanine transaminase (screen for fatty liver) |
| | Fasting lipid panel (screen for dyslipidemia) |
| Optional tests to be obtained on the basis of history, physical examination, and initial studies | Fasting serum glucose for those at high risk for diabetes mellitus |
| | Thyroid-stimulating hormone |
| | Drug screen |
| | Sleep study (if loud snoring, daytime sleepiness, or reported history of apnea) |
| | Complete blood count, especially in those with growth delay or abnormal renal function |

* Adapted from Wiesen J, Adkins M, Fortune S, et al. Evaluation of pediatric patients with mild-to-moderate hypertension: yield of diagnostic testing. *Pediatrics*. 2008;122(5). Available at: www.pediatrics.org/cgi/content/full/122/5/e988.

**Distinguishing clinical features between primary (essential) and secondary pediatric hypertension**

| Clinical features | Primary HTN | Secondary HTN |
|---|---|---|
| Age: | | |
| Prepubertal | | Secondary HTN is more likely in younger children, especially those less than six years of age. |
| Postpubertal | Older children and adolescents are more likely to have primary HTN. | |
| Diastolic HTN* | | Diastolic HTN is more likely to be associated with secondary HTN. |
| Nocturnal HTN* | | Nocturnal HTN is more likely to be associated with secondary HTN. |
| Overweight/obesity | Overweight or obese children/adolescents are more likely to have primary HTN. | |
| Family history of HTN | Children with a positive family history of primary HTN are more likely to have primary HTN. | Family history may be positive in some cases of secondary HTN due to a monogenic cause (eg, autosomal dominant polycystic kidney disease). |
| Symptoms of underlying disorder | Patients with primary HTN are typically asymptomatic. | Patients with secondary HTN often have other symptoms related to the underlying cause (eg, headache, sweating, and tachycardia due to catecholamine excess in patients with pheochromocytoma). |

HTN: hypertension; ABPM: ambulatory blood pressure monitoring.
* Nocturnal and diastolic hypertension are usually detected by ABPM.

# Who should be treated?

- Symptomatic HTN- headache, seizures, visual disturbances, focal deficits, indications of heart failure
- Stage 2 HTN
- Stage 1 HTN persisting despite a trial of 4-6 months of non pharmacologic therapy.
- Hypertensive end-organ damage- LVH. Retinal changes less common.
- Any stage of HTN or high BP for patients with CKD
- Any stage of HTN for patients with DM

**2017 American Academy of Pediatrics guidelines for follow-up of high blood pressure levels in children**

| BP screening schedule | Lifestyle counseling (weight and nutrition) | Check upper and lower extremity BP | ABPM* | Diagnostic evaluation ¶ | Initiate treatment | Consider subspecialty referral |
|---|---|---|---|---|---|---|
| **Normal BP** | | | | | | |
| Annual | X | – | – | – | – | – |
| **Elevated BP** | | | | | | |
| Initial measurement | X | – | – | – | – | – |
| Second measurement (repeat in six months) | X | X | – | – | – | – |
| Third measurement (repeat in six months) | X | – | X | X | – | X |
| **Stage 1 HTN** | | | | | | |
| Initial measurement | X | – | – | – | – | – |
| Second measurement (repeat in one to two weeks) | X | X | – | – | – | – |
| Third measurement (repeat in three months) | X | – | X | X | X | X |
| **Stage 2 HTN$^{\Delta}$** | | | | | | |
| Initial measurement | X | X | – | – | – | – |
| Second measurement (repeat, refer to specialty care within one week) | X | – | X | X | X | X |

BP: blood pressure; ABPM: ambulatory blood pressure monitoring; HTN: hypertension; ED: emergency department.
* ABPM is done to confirm HTN before initiating a diagnostic evaluation.
¶ Treatment may be initiated by a primary care provider or subspecialist.
Δ If the patient is symptomatic or BP is >30 mmHg above the 95$^{th}$ percentile (or >180/120 mmHg in an adolescent), send to an ED.

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# Management of the Obese Child with HTN

- DASH approach(Fruits, veg ,low fat milk products, whole grain, fish, poultry, nuts) and low salt diet(3.1g/day in 3-4 yrs; 3.8g/day in older
- Exercise (40minutes vigorous 3-5 days/weeks improve SBP by average 6.6 mmHg)
- Weight reduction (1mm fall for 1 kg reduction)
- Stress reduction (breathing awareness meditation, yoga)

*Joseph T. Flynn et al .AAP guidelines on clinical management of hypertension in children & adolescents Aug 2017*

# Choosing the right anti-HTN meds

- Depends on the etiology of HTN
- Associated co-morbidities
- Monitoring for adverse events

## Antihypertensive drugs for outpatient management of chronic hypertension for infants, children, and adolescents

| Drug | Age | Initial oral dose | Maximal oral dose per day | Dosing interval | Formulations |
|---|---|---|---|---|---|
| **ACE inhibitors** | | | | | |
| **Contraindications:** Pregnancy, angioedema.<br>**Common adverse effects:** Cough, headache, dizziness, asthenia.<br>**Severe adverse effects:** Hyperkalemia, acute kidney injury, angioedema, fetal toxicity. | | | | | |
| Benazepril | ≥6 years* | 0.2 mg/kg per day (up to 10 mg per day) | 0.6 mg/kg (up to 40 mg) | Daily. | Tablet: 5, 10, 20, 40 mg (generic).<br>Extemporaneous liquid: 2 mg/mL. |
| Captopril¶ | Infants | 0.05 mg/kg per dose | 6 mg/kg | Daily to 4 times a day. | Tablet: 12.5, 25, 50, 100 mg (generic).<br>Extemporaneous liquid: 1 mg/mL. |
| | Children | 0.5 mg/kg per dose | 6 mg/kg | Three times a day. | |
| Enalapril | ≥1 month* | 0.08 mg/kg per day (up to 5 mg per day) | 0.6 mg/kg (up to 40 mg) | Daily to twice a day. | Tablet: 2.5, 5, 10, 20 mg (generic).<br>Solution: 1 mg/mL. |
| Fosinopril | ≥6 years | 0.1 mg/kg per day (up to 5 mg per day) | 40 mg | Daily. | Tablet: 10, 20, 40 mg (generic). |
| | <50 kg | | | | |
| | ≥50 kg* | 5 mg per day | 40 mg | | |
| Lisinopril | ≥6 years* | 0.07 mg/kg per day (up to 5 mg per day) | 0.6 mg/kg (up to 40 mg) | Daily. | Tablet: 2.5, 5, 10, 20, 30, 40 mg (generic).<br>Solution: 1 mg/mL. |
| Ramipril¶ | NA | 1.6 mg/m$^2$ per day | 6 mg/m$^2$ | Daily. | Capsule: 1.25, 2.5, 5, 10 mg (generic). |
| Quinapril | NA | 5 mg per day | 80 mg | Daily. | Tablet: 5, 10, 20, 40 mg (generic). |
| **ARB** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Contraindications:** Pregnancy.<br>**Common adverse effects:** Headache, dizziness.<br>**Severe adverse effects:** Hyperkalemia, acute kidney injury, fetal toxicity. | | | | | |
| Candesartan | 1 to 5 years* | 0.02 mg/kg per day (up to 4 mg per day) | 0.4 mg/kg (up to 16 mg) | Daily to twice a day. | Tablet: 4, 8, 16, 32 mg.<br>Extemporaneous liquid: 1 mg/mL. |
| | ≥6 years* | | | | |
| | <50 kg | 4 mg per day | 16 mg | | |
| | ≥50 kg | 8 mg per day | 32 mg | | |
| Irbesartan | 6 to 12 years | 75 mg per day | 150 mg | Daily. | Tablet: 75, 150, 300 mg (generic). |
| | ≥13 years | 150 mg per day | 300 mg | | |
| Losartan | ≥6 years* | 0.7 mg/kg (up to 50 mg) | 1.4 mg/kg (up to 100 mg) | Daily. | Tablet: 25, 50, 100 mg (generic).<br>Extemporaneous liquid: 2.5 mg/mL. |
| Olmesartan | ≥6 years* | NA | NA | Daily. | Tablet: 5, 20, 40 mg.<br>Extemporaneous liquid: 2 mg/mL. |
| | <35 kg | 10 mg | 20 mg | | |
| | ≥35 kg | 20 mg | 40 mg | | |
| Valsartan | ≥6 years* | 1.3 mg/kg (up to 40 mg) | 2.7 mg/kg (up to 160 mg) | Daily. | Tablet: 40, 80, 160, 320 mg (generic).<br>Extemporaneous liquid: 4 mg/mL. |
| **Thiazide diuretics** | | | | | |
| **Contraindications:** Anuria.<br>**Common adverse effects:** Dizziness, hypokalemia.<br>**Severe adverse effects:** Cardiac dysrhythmias, cholestatic jaundice, new onset diabetes mellitus, pancreatitis. | | | | | |
| Chlorthalidone | Children | 0.3 mg/kg | 2 mg/kg (50 mg) | Daily. | Tablet: 25, 50, 100 mg (generic). |
| Chlorothiazide | Children* | 10 mg/kg per day | 20 mg/kg (up to 375 mg per day) | Daily to twice a day. | Tablet: 250, 500 mg (generic).<br>Suspension: 250/5 mL.<br>Extemporaneous liquid: 1 mg/mL. |
| Hydrochlorothiazide | Children* | 1 mg/kg per day | 2 mg/kg (up to 37.5 mg) | Daily to twice a day. | Tablet: 12.5, 25, 50 mg. |
| **Calcium channel blockers** | | | | | |
| **Contraindications:** Hypersensitivity to CCBs.<br>**Common adverse effects:** Flushing, peripheral edema, dizziness.<br>**Severe adverse effects:** Angioedema. | | | | | |
| Amlodipine | 1 to 5 years | 0.1 mg/kg | 0.6 mg/kg (up to 5 mg) | Daily. | Tablet: 2.5, 5, 10 mg.<br>Extemporaneous liquid: 1 mg/mL. |
| | ≥6 years* | 2.5 mg | 10 mg | | |
| Felodipine | ≥6 years | 2.5 mg | 10 mg | Daily. | Tablet (extended release): 2.5, 5, 10 mg (generic). |
| Isradipine | Children | 0.05 to 0.1 mg/kg | 0.6 mg/kg (up to 10 mg) | Capsule: Twice daily to 3 times a day.<br>Tablet (extended release): Daily. | Capsule: 2.5, 5 mg.<br>Tablet (extended release): 5, 10 mg. |
| Nifedipine extended release | Children | 0.2 to 0.5 mg/kg per day | 3 mg/kg (up to 120 mg) | Daily to twice a day. | Tablet (extended release): 30, 60, 90 mg (generic). |

ACE: angiotensin converting enzyme; NA: not applicable; ARB: angiotensin-receptor blocker; FDA: US Food and Drug Administration.
* FDA pediatric labeling.
¶ Dose per 24 hours should not exceed the usual maximum daily dose in adults.

# Summary

- Children >3 yrs seen in a medical setting should have their BP checked
- If BP > 90$^{th}$ % by oscillometric measures, it should be repeated manually
- If <3yrs with risk factors, then BP should be monitored e.g. renal disease, obesity
- ABPM should be done to confirm HTN
- Follow patients on meds q4-6wks until BP controlled
- Children > 6yrs do not require extensive evaluation for secondary causes if they have a family hx, overweight/obese and do not have a P/E suggestive
- It is pertinent to obtain a thorough history(including perinatal, dietary) and examination to id findings suggestive of secondary causes
- Rpt ECHO q6-12mthly to monitor improvement or progression

# Summary

- HTN failing lifestyle modification requires pharmacotherapy- ACE, ARB, Ca channel blocker or diuretic.
- Renal and reno-vascular causes account for most secondary HTN.
- Children with DM should be evaluated for HTN at each encounter.
- Adolescents with HTN who need transitioning should have appropriate documented transfer of care.

# Diagnostic Challenge:The Face of a Reninoma

S. Young Peart[1], C. Bernard[1], K. Muchantef[1], R. Jednak[1], L. Bell[1]

1. Montreal Children's Hospital, McGill University Health Centre

## INTRODUCTION

- ❖*Pediatric* hypertensive emergencies are uncommon
- ❖Encephalopathy is the usual manifestation
- ❖Facial nerve palsy is a very rare presentation of severe hypertension
- ❖Renal and reno-vascular problems account for most secondary hypertension in children
- ❖Reninomas are a rare cause of severe hypertension

## AIM

- ❖ To describe the presentation and management of a reninoma in an adolescent presenting with a facial nerve palsy

## METHOD/RESULTS

- ❖ A 13-year-old female presented with a 3-day history of right facial numbness and swelling and longstanding headache.
- ❖ Examination
  - ❖ Rt peripheral facial nerve paralysis
  - ❖ BP 198-215/130-146
  - ❖ No papilledema
- ❖ Investigations
  - ❖ Plasma K 2.4mmol/L, $HCO3^-$ 29mmol/L
  - ❖ Plasma renin >10.3ng/L/s (normal 0.21-1.06)
  - ❖ Aldosterone 520 pmol/L (normal 111-860)
- ❖ CT renal angiogram
  - ❖ Normal renal vessels
  - ❖ 6 mm hypo enhancement - left kidney lower pole
- ❖ MRI confirmed a 5 mm round lesion
- ❖ Renal vein sampling
  - ❖ Elevated renin from left kidney.

## METHOD/RESULTS

- ❖ HTN controlled with enalapril, amlodipine and hydrochlorothiazide
- ❖ Robotic laparoscopic surgery, with direct intraoperative renal ultrasound imaging (fig.1), resulted in complete excision of the lesion.
- ❖ Pathology
- ❖ Lesion encapsulated, measuring 1.0cm
- ❖ histological immunophenotype and ultrastructural findings (including intracytoplasmic rhomboid crystals) confirmed the diagnosis of reninoma ( figures 2-4)
- ❖ Blood pressure remained normal off medications post surgery. (105-110/62-70)

## DISCUSSION

- ❖ Mason 1st described association between peripheral facial nerve palsy and severe systemic hypertension > a century ago [8, 9]
  - ❖ In 19 of 23 patients, normalization of BP resulted in resolution of facial nerve palsy.
  - ❖ Persistently uncontrolled HTN resulted in partial resolution of facial nerve palsy
- ❖It is postulated that facial nerve dysfunction occurs as a result of
  - ❖ swelling of the facial nerve in its bony canal associated with vessel engorgement
  - ❖ hemorrhage into the facial canal or in the facial nerve nucleus
  - ❖ ischemic stroke affecting postnuclear fibers of the nerve [8,11]
- ❖Secondary hyperaldosteronism is responsible for hypokalemia
- ❖The definitive treatment is resection of the reninoma
- ❖Juxtaglomerular cell tumors (JCT) features:
  - ❖ Rare
  - ❖ Originate from smooth muscle cells of juxtaglomerular apparatus and contain renin secreting cells [2,5]
  - ❖Karyotyping of a small number of these tumors revealed a common loss of chromosomes 9 and 11[6]

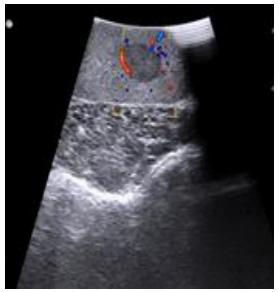

Figure 1
lesion during ultrasound guided robotic partial nephrectomy

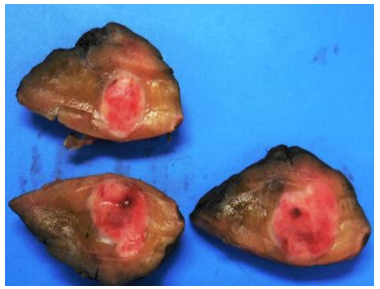

Figure 2
Gross appearance of encapsulated lesion on partial nephrectomy

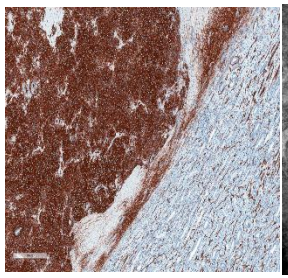

Figure 3
CD34 staining of lesion

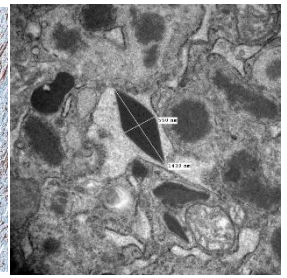

Figure 4
characteristic intracytoplasmic rhombhoid crystals

## CONCLUSIONS

- ❖Peripheral facial nerve paralysis, a rare complication of severe hypertension, led to the diagnosis of reninoma
- ❖ An abdominal MRI is the investigation of choice.
- ❖Although generally benign, long-term follow-up is warranted.

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## CONTACT INFORMATION

sandrica.youngpeart@mail.mcgill.ca

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# 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

# Thank you