

Pediatric hypertensive crisis

Doaa Youssef

Professor of pediatrics



a careful balance between decreasing blood pressure in a gradual manner while preventing damage end-organ damage.

evaluate any pediatric patient suspected of hypertensive emergency with a thorough workup while acutely treating the elevated blood pressure in a gradual manner





There are limited data related to acute severe hypertension in children and adolescents.

Most data are based on adult studies.

Agenda

- **Definition**
- **Epidemiology/ causes**
- **Pathophysiology**
- **Clinical picture**
- **Work up**
- **Treatment**
- **Question**

Agenda

- **Definition**
- Epidemiology/ causes
- Pathophysiology
- Clinical picture
- Work up
- Treatment
- Question

Definition

Hypertensive crisis is an acute episode of severely elevated blood pressure with potential for end-organ damage

While there are no specific cutoffs in terms of blood pressure for hypertensive crisis in pediatric as there are in the adult population, hypertensive crisis So it is primarily a clinical diagnosis which should be suspected in any pediatric patient with blood pressure at or exceeding the limits of stage II hypertension.

TABLE 2. Screening BP Values Requiring Further Evaluation

AGE, Y	BLOOD PRESSURE, MM HG			
	BOYS		GIRLS	
	SYSTOLIC	DIASTOLIC	SYSTOLIC	DIASTOLIC
1	98	52	98	54
2	100	55	101	58
3	101	58	102	60
4	102	60	103	62
5	103	63	104	64
6	105	66	105	67
7	106	68	106	68
8	107	69	107	69
9	107	70	108	71
10	108	72	109	72
11	110	74	111	74
12	113	75	114	75
≥13	120	80	120	80

Reprinted with permission from Flynn JT, Kaelber DC, Baker-Smith CM, et al; Subcommittee on Screening and Management of High Blood Pressure in Children. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics. 2017;140(3):e20171904

BP Categories and Stages in Children Aged 1-13 years

Normal BP	<90th percentile
Elevated BP	≥90th percentile to <95th percentile OR 120/80 mm Hg to <95th percentile (whichever is lower)
Stage 1 HTN	≥95th percentile to <95th percentile + 12 mm Hg, OR 130/80 to 139/89 mm Hg (whichever is lower)
Stage 2 HTN	≥95th percentile + 12 mm Hg, or ≥140/90 mm Hg (whichever is lower)

Then each year, add 1 mmHg each

HTN = 100/60

Age 3 – 103/63

5 – 105/65

7 – 107/67

9 – 109/69

11 – 111/71

13 – 113/73

In 2017, the American Academy of Pediatrics (AAP) published new clinical practice guidelines (CPG) for the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents.

The new guidelines recommend screening for BP abnormalities in children ≥ 3 years old at the annual preventative visit as opposed to every healthcare encounter.

New blood pressure values (1–18 years)

In the previous guideline from 2014, an important portion of the children who were included in the percentile table (**21%**) consisted of **overweight** and obese children .

Therefore, the new BP values are **below** the 2004 values .

Although the new guidelines explicitly describe the many causes of secondary hypertension, the diagnostic workup for patients with sustained hypertension is also streamlined because of the increasing prevalence of primary hypertension

the current CPG recommended goal of therapy is now < 90th percentile in most children and even lower in special populations such as children with chronic kidney disease.

Hypertensive crisis can be subcategorized as

- hypertensive **urgency**, in which there are no signs of end-organ damage,
- hypertensive **emergency**, in which signs of endorgan damage are present.

Complications of Hypertension: Target-Organ Damage



TIA, transient ischemic attack; LVH, left ventricular hypertrophy; CHD, coronary heart disease; HF, heart failure

Agenda

- **Definition**
- **Epidemiology/ causes**
- Pathophysiology
- Clinical picture
- Work up
- Treatment
- Question

EPIDEMIOLOGY

The epidemiology of hypertensive crisis in children is difficult to pinpoint due to **variations in diagnostic criteria** and paucity of relevant literature.

In a recent survey conducted by the National Health and Nutrition Examination Survey (NHANES) in preadolescent and adolescent patients, the morbidity of hypertensive crisis was found to be between 1 and 4% .

Several retrospective studies conducted in the emergency room (ER) have shown the prevalence of hypertensive crisis among those presenting with HTN to range from 16 to 54%.

With the wide range of prevalence found for hypertensive crisis in the pediatric population, more multicentered studies are needed to accurately identify the true prevalence of hypertensive crisis in this population.

Risk Factors

- BMI that exceeds the 95th percentile
- Preexisting hypertension
- less effective outpatient systolic blood pressure control

Primary hypertension

In the United States, primary hypertension is the most common cause of hypertension observed in children and adolescents

Its general characteristics are as follows:

it is observed in older children (≥ 6 years),

familial history is positive (mother/father and or grandmother/grandfather),

and it is associated with overweight/obesity.

Primary and secondary hypertension cannot be predicted according to blood

pressure values, but it is thought that increased DBP indicates secondary

hypertension in particular, and increased SBP indicates primary hypertension.

According to the AAP guideline, detailed investigation is not necessary if the child is aged 6 years or above and overweight or obese, familial history is positive, and a physical examination and history do not suggest secondary hypertension.

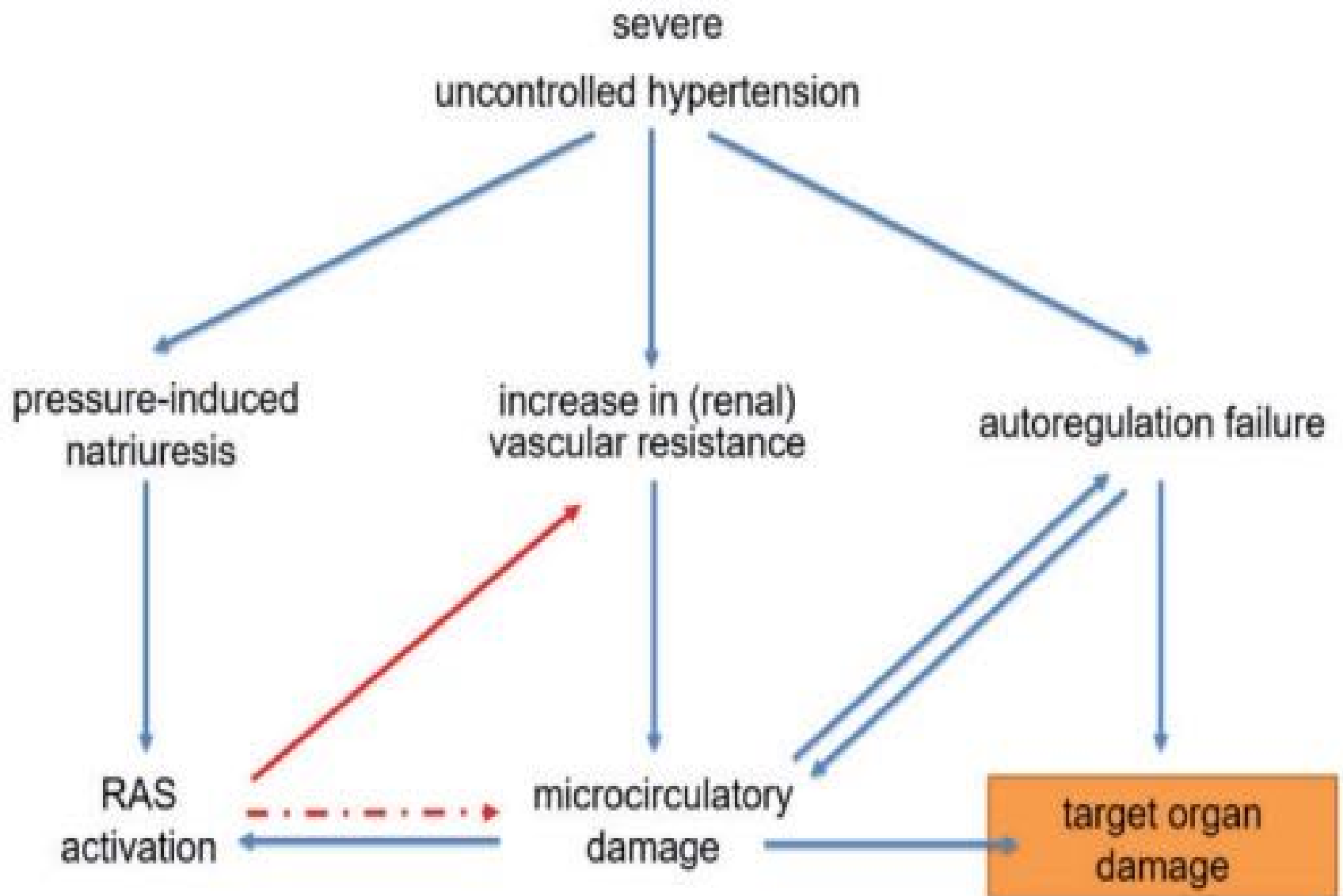
Common causes of hypertension in children

Newborns	Renal vein thrombosis Renal artery stenosis Congenital renal anomalies Coarctation of aorta
Infants to 6 years old	Renal parenchymal disease Renovascular disease Coarctation of aorta
School age, 6-10 years	Renal parenchymal disease Renovascular disease Essential hypertension
Adolescents	Essential hypertension Renal parenchymal disease Renovascular disease

*Think about rarer endocrine causes in all age groups...
hyperthyroidism,
phaeochromocytoma,
Cushing's disease*

Agenda

- **Definition**
- **Epidemiology/ causes**
- **Pathophysiology**
- Clinical picture
- Work up
- Treatment
- Question



- Severe hypertension induces changes in the renal arterioles that lead to;
 - ✓ endothelial damage,
 - ✓ platelet and fibrin deposition, and
 - ✓ thromboxane release.
- This cascades into
 - ✓ vasoconstriction,
 - ✓ ischemia,
 - ✓ Myointimal proliferation, and
 - ✓ decompensation of autoregulatory mechanisms, resulting in hypoperfusion to the:
 - heart,
 - kidney, and
 - brain.

Agenda

- **Definition**
- **Epidemiology/ causes**
- **Pathophysiology**
- **Clinical picture**
- Work up
- Treatment
- Question

- Hypertensive crisis can be a source of morbidity and mortality in the pediatric.
- it is well-known that secondary causes of pediatric hypertension contribute to a greater incidence of hypertensive crisis in pediatrics.
- Hypertensive crisis may manifest with non-specific symptoms as well as distinct and acute symptoms in the presence of end-organ damage.



Hypertensive changes on fundoscopy
Retinal bleeding
'Cotton wool' lesions

Increased ICP
Papilloedema

Encephalopathy

Reduced GCS
Headaches
Nausea and vomiting
Bells Palsy
Hemiparesis
Altered vision
Seizures

Heart failure

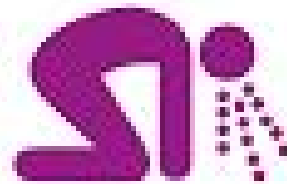
Cardiomegaly
Gallop Rhythm
Breathlessness
Pulmonary oedema



Severe chest pain



Headache & blurred vision



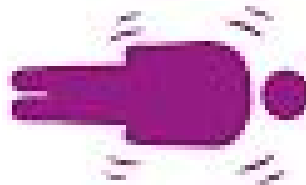
Nausea & vomiting



Severe anxiety



Shortness of breath



Seizures



Unresponsiveness

Agenda

- **Definition**
- **Epidemiology/ causes**
- **Pathophysiology**
- **Clinical picture**
- **Work up**
- **Treatment**
- **Question**

Laboratory Findings

- Initial laboratory studies should include:
 - Complete blood count
 - Electrolytes
 - Blood urea nitrogen
 - Serum creatinine
 - Serum calcium
 - Urinalysis
 - Chest radiography
 - Electrocardiography

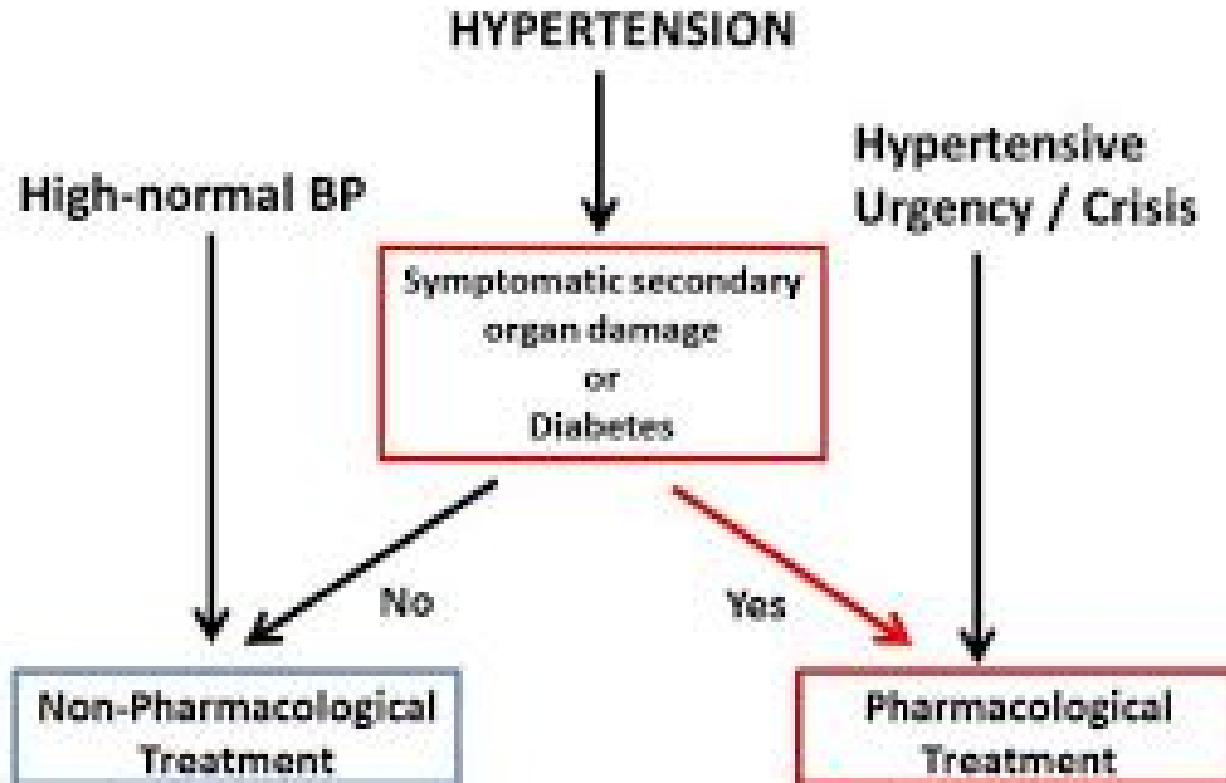
- Imaging tests for diagnosis of hypertensive crisis
 - ✓ Chest radiography
 - ✓ Intravenous pyelography
 - ✓ Voiding cystourethrography
 - ✓ Cardiac catheterization
 - ✓ Renal ultrasonography
 - ✓ Renal scan
 - ✓ Renal arteriography



Agenda

- **Definition**
- **Epidemiology/ causes**
- **Pathophysiology**
- **Clinical picture**
- **Work up**
- **Treatment**
- **Question**

Treatment



• Oral treatment should be considered if the patient can use oral medication and life-threatening complications are absent.

• Intravenous agents should be considered if oral intake is not possible and the patient's clinical status is not stable or severe complications are present (such as congestive heart failure).

Treatment of hypertensive urgency

- Oral antihypertensive agents are generally sufficient, although parenteral therapy is sometimes indicated.
- Theories suggest:
 - One-third of total planned BP reduction during the first 6 hours
 - Another third during next 24–36 hours
 - Final third during next 24–96 hours or longer

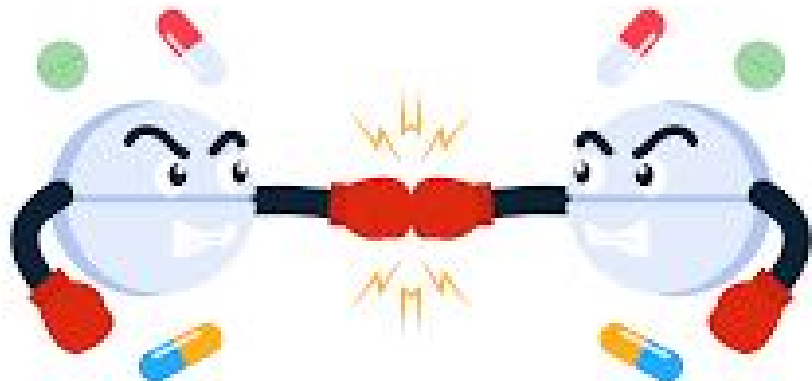




Table 6. Antihypertensive drugs and doses (1)

Drug class	Drug	Initial dose	Maximum dose	Daily intervals	Contraindications
ACE inhibitors	Captopril	0.3-0.5 mg/kg/dose	6 mg/kg	2-3 doses	Pregnancy, hyperkalemia, single kidney
	Enalapril	0.08-0.6 mg/kg		Single dose	
	Ramipril	1.5-6mg		Single dose	
ARBs	Losartan	0.7 mg/kg-50 mg	1.4 mg-100 mg	Single-two doses	or renal artery stenosis, renal artery stenosis in both kidneys
Calcium channel blockers	Amlodipine	0.06-0.3 mg/kg	5-10 mg	Single dose	Congestive heart failure
	Nifedipine (extended release form)	0.25-0.5 mg/kg	3 mg/kg -120 mg	Single-two doses	
Diuretic	Amiloride	0.4-0.6 mg/kg	20 mg	Single dose	Sports people, diabetes mellitus
	Furosemide	0.5-2 mg/kg	6 mg/kg	Single-two doses	
	Spirolactone	1 mg/kg	3.3 mg/kg-100 mg	Single-two doses	
	Hydrochlorothiazide	0.5-1 mg/kg	3 mg/kg/day	Single-two doses	
Beta blocker	Atenolol	0.5-1 mg/kg	2 mg/kg-100 mg	Single-two doses	Asthma
	Propranolol	1 mg/kg	4 mg/kg-640 mg	2-3 doses	
Central alpha-blocker	Clonidine	0.2 mg/kg	2.4 mg	2 doses	
Peripheral alpha-blocker	Doxazosin	1 mg	4 mg	Single dose	
	Prazosin	0.05-0.1 mg/kg	0.5 mg/kg	3 doses	
Vasodilator	Hydralazine	0.75 mg/kg	7.5 mg/kg-200 mg	4 doses	
	Minoxidil	0.2 mg/kg	50-100 mg	Single-3 doses	

Drugs used in hypertensive urgency

Drug	Class	Route	Dose	Adverse effects
Furosemide	Diuretic	IV/PO	1-2 mg/kg/dose	Electrolyte disturbances
Nifedipine	Ca ⁺⁺ channel blocker	Sub-lingual / PO	0.1-0.25 mg/kg/dose	Precipitous drop in blood pressure; tachycardia; headache
Clonidine	Central α agonist	PO	0.05-0.3 mg	Rebound hypertension; sedation
Minoxidil	Vasodilator	PO	0.1-2 mg/kg/dose	Pericardial effusion

Drugs used in hypertensive emergency

Drug	Class	Route	Dose	Adverse Effect
Nicardipine	Ca ⁺⁺ channel blocker	IV	1-3 mcg/kg/min	Headache; increased intracranial pressure
Labetalol	α and β blocker	IV in infusion	0.25-1.5 mg/kg/hr 0.2-1 mg/kg/dose Maximum 20mg/dose	Use with caution in hyperkalemia and CHF
Esmolol	β blocker	IV	Bolus 100-500 mcg over 1 min; 25-100 mcg/kg/min; can increase to 500 mcg/kg/min	Can cause CHF, bradycardia and bronchospasm; contraindicated in cocaine toxicity
Hydralazine	Vasodilator	IV	0.1-0.5 mg/kg/dose. every 4-6 h	Tachycardia, flushing, Lupus like syndrome
Sodium nitroprusside	Vasodilator	IV	0.5-0.8mcg/kg/min	Thiocyanate toxicity with decreased renal function

Preferred Parenteral Drugs for Selected Hypertensive Emergencies

EMERGENCIES	PARENTERAL DRUGS
Hypertensive encephalopathy	Nitroprusside, nicardipine, labetalol
Malignant hypertension (when IV therapy is indicated)	Labetalol, nicardipine, nitroprusside, enalaprilat
Myocardial infarction/unstable angina	Nitroglycerin, nicardipine, labetalol, esmolol
Acute left ventricular failure	Nitroglycerin, enalaprilat, loop diuretics
Adrenergic crisis	Phentolamine, nitroprusside
Postoperative hypertension	Nitroglycerin, nitroprusside, labetalol, nicardipine

Treatment-resistant hypertension

Treatment-resistant hypertension is defined as persistence of hypertension despite intake of three or more antihypertensive drugs at the highest doses

- One should be sure that treatment is received at the recommended doses.
- Renovascular hypertension should be considered primarily in the differential diagnosis.
- Renal Doppler USG, MR or CT angiography may be planned according to the clinical status.
- Renin-aldosterone values and serum electrolytes may give information in terms of monogenic hypertension.
- Ambulatory blood pressure measurements may be used to confirm the diagnosis.

Treatment consists of

- salt restriction,
- avoidance of substances that may increase blood pressure,
- investigation and elimination of the cause of secondary hypertension that could not be diagnosed previously.

In pharmacologic treatment,

- extended release drugs should be preferred and the highest dose that will not lead to adverse effects should be used.
- All drugs should be used as instructed, and one of these drugs should be a diuretic
- Clinical studies have shown that the addition of aldosterone receptor blockers (such as spironolactone) is helpful in the treatment of undiagnosed hyperaldosteronism and in the elimination of excess volume in adults.
- There are insufficient data related to this issue in children for those patients.

Renal insufficiency

- It can be a cause or consequence of hypertensive emergency.
- Particularly noted in patients on haemodialysis; those on EPO therapy; and in patients with renal transplants, especially those receiving cyclosporin and corticosteroids
- The primary goal of management is to limit further renal damage through blood pressure control
- Antihypertensive drugs that preserve renal blood flow, such as calcium antagonists and α -adrenergic blocking agents are appropriate.
- In refractory hypertension, other vasodilators such as sodium nitroprusside, fenoldopam or hydralazine

TABLE 4 | Endocrine parameters and treatment of diseases with monogenic hypertension.

Condition	Phenotype MIM	Gene/Locus MIM	Pattern of inheritance	Age	Potassium	Renin (PRA)	Aldosterone	Aldo: PRA ratio	Glucocorticoid Resp.	Mineralo corticoid receptor blocker Resp.	Treatment
Liddle's	177200	600760	AD	Child Adult	N or ↓	↓	↓		-	-	Amloride, Triamterene
Gordon's	145260	-	AD	Child Adult	N or ↑	↓	N or ↑		-	-	Triamterene
FMI	218030	614232	AR	Infant Child Adult	↓ (N)	↓	↓		-		Mineralocortico id rec, antagonist
H-P	605115	600983	AD	Child Adult	N or ↓	↓	↓			reversed	Amloride, Triamterene Thiazide
GRA	10390	610613	AD	Infant Child	N or ↓	↓	↑	↑			Amloride, Triamterene
FHD	605635	600570	AD	Adult	N or ↓	↓	↑	↑	-		Mineralocortico id rec, antagonist

Pediatric Hypertensive Emergency/Urgency

(ED, Inpatient)

INCLUSION CRITERIA

Age: 1-18 years old

- Age 1-13 years: BP > 95th percentile + 12 mmHg (see BP tables on the following page)¹ or >140/90 mmHg with symptoms.^{2,3}
- Age >13 years: >30mmHg above 95th percentile or >180/120 mmHg
- Consider Nephrology consult for patients with chronic hypertension

EXCLUSION CRITERIA

NICU patients or any patient with suspicion of pheochromocytoma (episodic headache, sweating, tachycardia, HTN)

START

Provider Assessment
 "Measure and document appropriate for patient's culture by
 "Measure patient's culture when BP is checked"

Symptomatic?

- Headache
- Visual changes
- Altered mental status
- Seizure
- Chest pain

** Additional Information **

- Patients should have height measured to determine BP percentile
- Labetalol contraindicated in patients with asthma, severe bradycardia, greater than 1st degree heart block. Also contraindicated in suspected pheochromocytoma
- Esmolol contraindicated in patients with asthma and heart failure

Evaluate for end-organ damage:

- Electrolytes
- SUN/Creatinine
- UPTs
- Urinalysis
- ECG
- Echocardiogram
- CRP
- Nephrology consult

Absent

Fluid overload?
 (pulmonary edema, positive fluid balance, increased weight)

Yes

Anuric at baseline?

Yes

Dialysis

No

Furosemide IV/PO

Present

- Establish IV access
- PCU evaluation
- IV bolus: hydralazine (first line) or labetalol^{2,3}
- Followed by continuous infusion: nicardipine (first line), esmolol^{2,3}

CT head if hypertensive encephalopathy present:

- Electrolytes
- SUN/CR
- UPTs
- Urinalysis
- ECG
- Echocardiogram
- CRP
- Renal ultrasound

No

First line: lisinopril PO
 Alternatives: clonidine PO, nifedipine PO, hydralazine PO

Evaluate for cause:

- Urine catecholamines
- Urine tox screen
- Plasma metanephrines
- Plasma renin and aldosterone
- Cortisol level
- Renal ultrasound with Doppler
- Serum lipid profile
- Serum CS complement
- Calcium, phosphorus, uric acid

Re-check blood pressure in 30 min. Improved?

Yes

Close MD monitoring. Recheck BP in 2 hours, if continuing to improve, may return to q-4h BP checks

No

Repeat oral dose x2. If still no response: hydralazine IV, labetalol IV

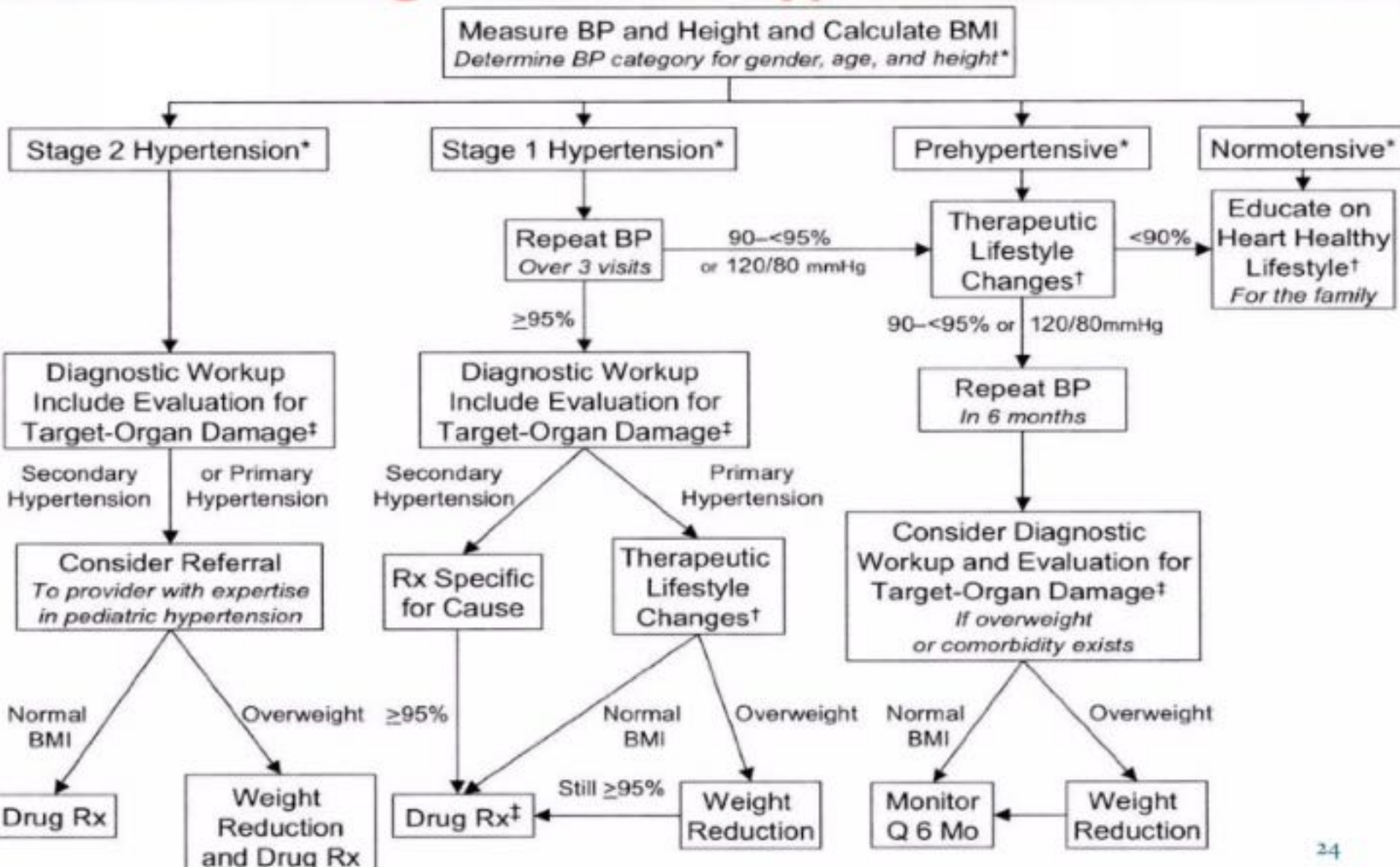
No response to two doses of IV anti-hypertensives? Refer to PCU for evaluation

END

Goal Blood Pressure:

- <95th percentile for age/sex/height if NO end-organ damage
- <90th percentile if end-organ damage present
- Decrease BP...
 - 25% in first 8-12 hrs

Treatment algorithms for hypertensive crisis



Hypertension in Children

Updated on April 1, 2018 By thoreczko 0 Comments



PEDIATRIC EMERGENCY PLAYBOOK
Hypertension in Children

30h

00:00:00 / 00:30:45

↑30



#libsyn



CONCLUSION

- Patients with hypertensive emergencies may require immediate reduction in elevated blood pressure to prevent and arrest progressive end-organ damage.
- The best clinical setting in which to achieve this blood pressure control is in the intensive care unit, with the use of titratable intravenous hypotensive agents.
- The appropriate therapeutic approach in each patient will depend on the clinical presentation.

REFERENCES

- Raina et al. Pediatric Hypertensive Crisis, *Frontiers in Pediatrics* | www.frontiersin.org 1 October 2020
- Jameson, J. L., Kasper, D. L., Longo, D. L., Fauci, A. S., Hauser, S. L., and Loscalzo, J., (Eds.), (2018). *Harrison's Principles of Internal Medicine (20th Edition). Volume I*. New York: McGraw-Hill Education. Pp. 1890-1906.
- Rodriguez, M. A., Kumar, S. K., and De Caro, M., (2010). Hypertensive crisis. *Cardiology in Review*; 18(2):102-107.
- Van den Born, B. H., Lip, G. Y. H., Brguljan-Hitij J., Cremer, A., Segura, J., Morales, E., Mahfoud, F., Amraoui, F., Persu, A., Kahan, T., Rosei, E. A., Simone, G., Gosse, P., and Williams, B., (2018). ESC council on hypertension position document on the management of hypertensive emergencies. *European Heart Journal – Cardiovascular Pharmacology*; 1-10
- Varon, J., and Mark, P. E., (2003). Clinical review: The management of hypertensive crises. *Critical care*; 7(5):374-384
- Vaughan, C. J., and Delanty, N., (2000). Hypertensive emergencies. *Lancet*; 356:411-17.

1- in hypertensive crisis

- A- we target 90% control in 1st 4 hrs
- B- target organ damage depend is unavoidable
- C- can be treated with oral antihypertensives

2- As regard monogenic hypertension

- A- best is to treat with vasodilators
- B- difficult to control
- C- must be Admitted to PICU

3- A child experiencing PRES

- A- would be left with brain damage
- B- need high index of suspicious
- C- lesions are only limited to posterior brain