National Guideline for Management of Paediatric Hypertension

Ministry of Health

Male', Republic of Maldives

RELEASE RECORD

Version No	Version Date	Description of change
1	30 January 2024	Initial release

DOCUMENT NUMBER: MOH-QA/G/24/161-0

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Published by Quality Assurance and regulations Division

Ministry of Health, Male, Republic of Maldives

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1. INTRODUCTION

Hypertension in childhood and adolescence contributes to premature atherosclerosis and the early development of cardiovascular disease. The diagnosis of persistent childhood hypertension is made when repeat Blood Pressure (BP) values on three separate visits are in accordance with the definitions in table 1. Additional description of classification of hypertension in children and adolescents are in table 2.

- Children <16 years – BP ≥95th percentile for age, sex, and height, **or** ≥130/80 mmHg (whichever is lower) **(blood pressure levels by age and percentile of height for girls and boys are in Appendix 1)**
- Children ≥16 years – BP ≥130/85

The diagnosis of hypertension is made when the auscultated BP values exceed these thresholds on three repeated and separate visits.

Table 1: Definitions for Paediatric blood pressure categories. 2017 American Academy of Paediatrics.

	For Children aged 1 to <13 years	For Children aged >= 13 years
Normal BP	Systolic and diastolic BP <90th percentile	Systolic BP <120 and diastolic BP <80 mmHg
Elevated BP	Systolic and diastolic BP ≥90th percentile to <95th percentile **or** 120/80 mmHg to <95th percentile (whichever is lower)	Systolic BP 120 to 129 and diastolic BP <80 mmHg
Stage 1 HTN	Systolic and diastolic BP ≥95th percentile to <95th 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 ≥95th percentile **+** 12 mmHg **or** ≥140/90 mmHg (whichever is lower)	≥140/90 mmHg

Table 2: Classification of hypertension in children and adolescents

Category	0-15 years SBP and/or DBP Percentile	16 years and older SBP and/or DBP Percentile (mmHg)
Normal	<90th	<130/85
High-normal	≥90th to <95th percentile	130-139/85-89
Hypertension	≥95th percentile	≥140/90
Stage 1 Hypertension	95th percentile to the 99th percentile and 5 mmHg	140-159/90-99
Stage 2 Hypertension	>99th percentile plus 5 mmHg	160-179/100-109
ISH	SBP ≥95th percentile and DBP <90th percentile	≥140/<90

ISH: Isolated Systolic Hypertension

2. SCREENING

Screening BP is performed as follows:

- For children without risk factors or conditions associated with hypertension, BP is measured beginning at three years of age during annual health care supervision visits.
- For children <3 years of age with risk factors for hypertension, BP is measured at each health supervision visit. See table 3 for risk factors for hypertension in children < 3 years.
- For children ≥3 years of age with risk factors for hypertension, BP is measured at every health care encounter. See table 4 for risk factors for hypertension in children < 3 years.

Table 3: Risk factors for hypertension in children <3 years

Check BP at health supervision visits for children with the following: *
Perinatal risk factors: • Born at <32 weeks gestation • Small for gestational age • Birth weight <1500 g • Neonatal complications that required intensive care or umbilical artery catheterization
Recurrent urinary tract infection, haematuria, or proteinuria
Renal disease or urologic malformation
Family history of congenital renal disease
Solid organ or hematopoietic cell transplant
Malignancy or other systemic illness associated with hypertension (eg, neurofibromatosis, tuberous sclerosis complex, sickle cell disease)
Treatment with drugs known to raise blood pressure (eg, caffeine, nonsteroidal anti-inflammatory drugs, glucocorticoids)
Evidence of elevated intracranial pressure

** For children without risk factors, BP should be measured annually at health supervision visits beginning at age 3 years.*

Table 4: Risk factors for hypertension in children ≥3 years

Check BP at all health encounters for children with the following: *
Obesity
Type 1 or type 2 diabetes
Renal disease
History of aortic arch obstruction or coarctation
Treatment with or taking drugs known to increase blood pressure: • Decongestants • Caffeine • Nonsteroidal anti-inflammatory drugs • Glucocorticoids • Stimulants • Hormonal contraception • Tricyclic antidepressants • Amphetamines • Cocaine

** For children without risk factors, BP should be measured annually at health supervision visits beginning at age 3 years.*

Children with systolic BP (SBP) or diastolic BP (DBP) that exceeds screening thresholds for age and sex, require further evaluation, starting with repeat BP measurement. See table 5 and 6. Additionally, the guideline for follow-up of high blood pressure levels in children are in table 7.

Table 5: Screening Blood Pressure requiring further evaluation.

Age (years)	BP (mmHg)			
	Males		Females	
	Systolic BP	Diastolic BP	Systolic BP	Diastolic BP
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

This table is designed as a screening tool only for the identification of children and adolescents who need further evaluation of their BP, starting with repeat BP measurements. The table should not be used by itself to diagnose elevated BP or hypertension.

Table 6: Neonatal blood pressures and potential treatment parameters.

Postmenstrual 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
D8P	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 2 weeks of age in infants from 26 to 44 weeks postmenstrual age. The 95th and 99th percentile values are intended to serve as a reference to identify infants with persistent hypertension that may require treatment.

Table 7: Guidelines for follow-up of high blood pressure levels in children. American Academy of Paediatrics (2017)

BP Screening Schedule	Lifestyle Counselling (Weight & 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 6 months)	X	X	-	-	-	-
Third Measurement (repeat in 6 months)	X	-	X	X	-	X
Stage 1 HTN						
Initial Measurement	X	-	-	-	-	-
Second Measurement (repeat in 1 to 2 weeks)	X	X	-	-	-	-
Third Measurement (repeat in 3 months)	X	-	X	X	X	X
Stage 2 HTN						
Initial Measurement	X	X	-	-	-	-
Second Measurement (repeat, refer to specialty care within 1 week)	X	-	X	X	X	X

BP: Blood Pressure; ABPM: Ambulatory Blood Pressure Monitoring: HTN: Hypertension.

** Ideally if available ABPM is done to confirm HTN before initiating a diagnostic evaluation.*

§ Treatment may be initiated by a primary care provider or subspecialist.

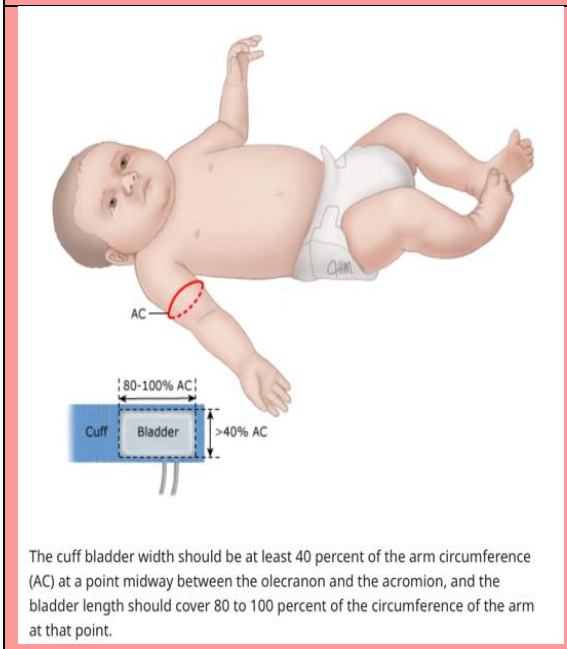
Δ If the patient is symptomatic or BP is >30 mmHg above the 95th percentile (or >180/120 mmHg in an adolescent), send to an emergency department.

3. MEASURING BLOOD PRESSURE

3.1 Technique to ensure accurate measurements of BP include:

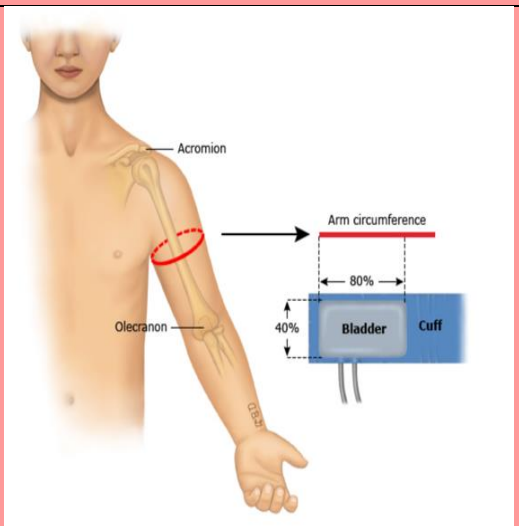
- Use an appropriately sized cuff, defined as a bladder width of 40 percent of the circumference of the upper arm and a bladder length that encircles 80 to 100 percent of the circumference of the upper arm. See figure 1 and 2.
- Perform the BP measurement in the right arm after the patient has been resting comfortably for at least three minutes in a seated position in a quiet environment.
- If the BP value exceeds the 90th percentile by oscillometry, confirm it with an auscultatory measurement.
- In the initial evaluation for hypertension, perform BP measurements in both upper and lower extremities.
- At each visit, obtain at least two BP measurements spaced one or two minutes apart.
- When performing an auscultatory BP measurement, use the first (initial tapping sound) and fifth (disappearance) Korotkoff sounds to identify SBP and DBP values, respectively.

Figure 1: Determining appropriate BP cuff size for neonates



The cuff bladder width should be at least 40 percent of the arm circumference (AC) at a point midway between the olecranon and the acromion, and the bladder length should cover 80 to 100 percent of the circumference of the arm at that point.

Figure 2: Determining appropriate BP cuff size for children



The width of the bladder of the blood pressure cuff should be approximately 40% of the circumference of the upper arm midway between the olecranon and the acromion. The length of the bladder of the cuff should encircle 80 to 100% of the circumference of the upper arm at the same position.

3.1 Ambulatory BP monitoring

Where available, ABPM should be used to confirm the diagnosis of hypertension in children. ABPM provides multiple measurements during regular activities (including sleep) and may give a more accurate description of the patient's BP and circadian patterns.

4. RISK FACTORS OF HYPERTENSION IN CHILDREN AND ADOLESCENTS

4.1 Modifiable risk factors

Modifiable risk factors include high dietary sodium intake, overweight or obesity, lack of breastfeeding as an infant, obstructive sleep apnea, exposure (active or passive) to tobacco smoke, lack of physical activities, prenatal and neonatal factors (LBW, preeclampsia) and adverse childhood experiences including abuse, neglect, parental mental health problems and household dysfunction. In addition, white coat and masked HTN appear to increase the risk of primary HTN.

4.2 Nonmodifiable risk factors

Nonmodifiable risk factors include male sex, and having a positive family history for HTN.

5. ETIOLOGY

The etiology of paediatric chronic HTN is divided into two categories:

5.1Primary HTN, in which no underlying cause is identified.

- A family history of HTN is present in as many as 70 to 80 percent of all patients with primary HTN. In patients with primary HTN, elevated blood pressure (BP) is thought to result from the interaction of multiple genes and environmental factors.

5.2 Secondary HTN, in which an underlying cause is identified. See table 8 for the causes of secondary hypertension in children and adolescents.

- The most common condition resulting in secondary HTN is kidney disease, followed by endocrine and renovascular diseases. Rarely, monogenic disorders, such as glucocorticoid-remediable aldosteronism, autosomal polycystic kidney disease, and Liddle syndrome, can cause HTN.

Table 8: Causes of secondary hypertension in children and adolescents

Kidney Disease	Psychologic Causes
- **Pyelonephritis**	- Mental stress
- Kidney parenchymal disease	- Anxiety
- Congenital anomalies	
- **Reflux nephropathy**	**Pharmacologic Causes**
- **Acute glomerulonephritis**	- Sympathomimetics
- Henoch-Schoenlein purpura	- Corticosteroids
- Kidney trauma	- Stimulants
- Hydronephrosis	- Oral contraceptives
- Haemolytic uremic syndrome	- Anabolic steroids
- Kidney stones	- Cocaine
- Nephrotic syndrome	- Phencyclidine (PCP)
- Wilms tumour	- Licorice
- Hypoplastic kidney	- Nicotine
- Polycystic kidney disease	- Caffeine
Endocrine Disease	**Vascular Disease**
- **Hyperthyroidism**	- Renal artery abnormalities
- Congenital adrenal hyperplasia	- Renal vein thrombosis
- Cushing syndrome	- Coarctation of the aorta
- Primary aldosteronism	- Patent ductus arteriosus
- Primary hyperparathyroidism	- Arteriovenous fistula
- Diabetes mellitus	
- **Hypercalcemia**	**Other Causes**
- **Pheochromocytoma**	- Neuroblastoma
	- Heavy metal poisoning
Neurologic Causes	- Acute pain
- Increased intracranial pressure	- Collagen vascular diseases
- Guillain-Barré syndrome	- Neurofibromatosis
	- Tuberous sclerosis

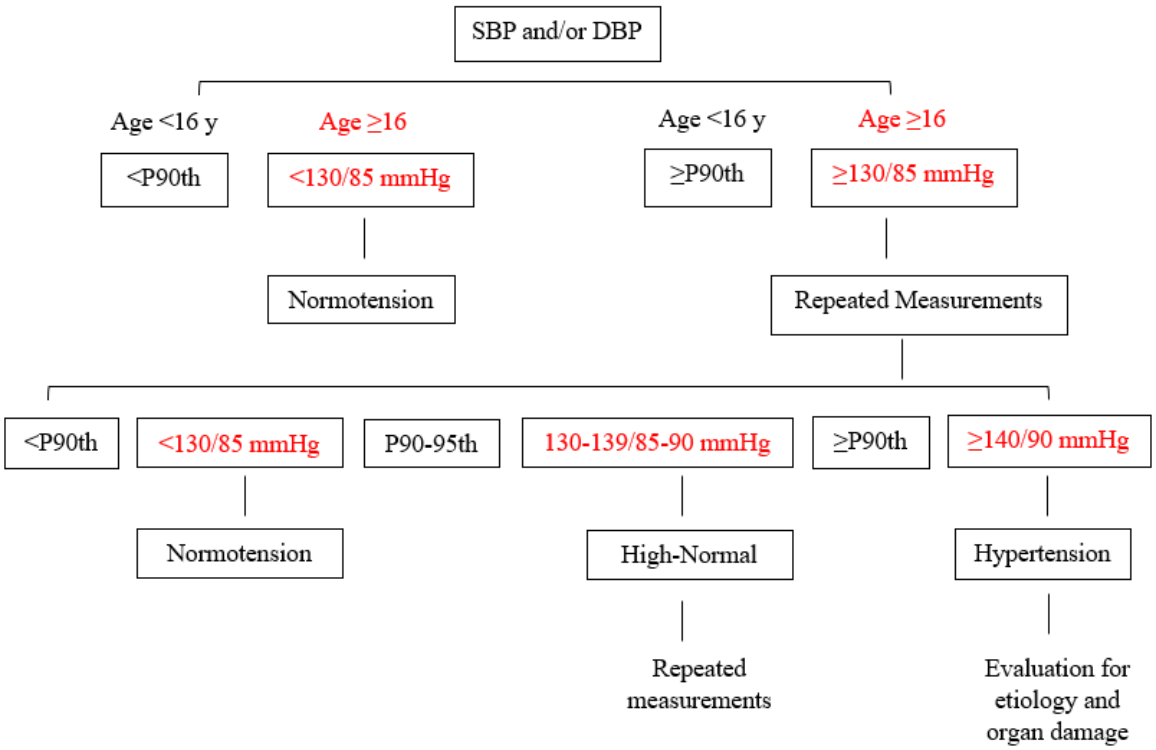
6. DIAGNOSIS AND INVESTIGTIONS

6.1 Diagnostic evaluation of hypertension in children and adolescents

The goals of the evaluation of a child or adolescent with HTN include:

1) Determining whether the patient is more likely to have primary (essential) or secondary HTN. Identify any treatable conditions that may be causing or contributing to HTN. Children with likely secondary HTN need further evaluation and management by a specialist experienced in childhood HTN.
2) Identify other comorbid conditions or risk factors for early CVD (e.g., obesity, dyslipidemia, diabetes mellitus).
3) Identify children for whom antihypertensive drug therapy is indicated.
4) Identify hypertensive complications. Figure 3 describes the flow chart for diagnosis of hypertension based on percentile distribution of age, sex and height.

Figure 3: Flowchart for the diagnosis of hypertension based on percentile distribution of age, sex and height.



Flowchart for the diagnosis of hypertension based on percentile distribution of age, sex and height. Less than 16 years and on defined threshold at least 16 years.

6.2 History and physical examination

A detailed history should be undertaken, focusing to differentiate between primary and secondary hypertension and also assessing for symptoms consistent with hypertensive emergencies. See table 9 for required clinical history of the patient

Physical examination should assess for findings suggestive of end organ damage due to HTN like retinal vascular changes due to HTN and abnormal cardiac findings. See table 10 for details of physical examination of the patient.

Table 9: Clinical History

Family history
Hypertension Diabetes Dyslipidaemia Cardiovascular disease Hereditary renal disease (polycystic kidney disease and Alport syndrome) Hereditary endocrine disease (adrenal tumours, glucocorticoid-remediable aldosteronism, multiple endocrine neoplasia type 2 and monogenic syndromes of hypertension) Syndromes associated with hypertension (neurofibromatosis)
Clinical history
1. History or symptoms of secondary hypertension: Perinatal history: oligohydramnios, anoxia, umbilical artery catheterization and renal artery/vein thrombosis Underlying or concurrent diseases:- - Renal or urologic disease, trauma, recurrent urinary tract infections, oedema, weight loss, failure to thrive, thirst/polyuria, nocturia and haematuria - "Cardiac, endocrine, or neurological disease, cold extremities, intermittent claudication, palpitations, sweating, fever, pallor, flushing, muscle weakness, crumbs, virilization, primary amenorrhea, male pseudo hermaphroditism and skin abnormalities"

- Systemic disease (lupus erythematosus) Drug/substance intake: steroids, calcineurin inhibitors, TCAs, decongestants, oral contraceptives, amphetamines and cocaine 2. History or symptoms of target organ damage: Headache, epistaxis, vertigo, visual impairment, facial palsy, strokes, low school performance, dyspnoea, chest pain, palpitations syncope
Risk factors
Diabetes mellitus Dyslipidaemia Obesity and growth patterns Physical exercise and dietary habits Smoking/ vaping and alcohol Birth weight and gestational age Snoring and sleep apnoea history
Hypertension onset and management
Age at presentation Previous blood pressure measurements Past and current treatment Compliance-adverse effects

Table 10: Physical Examination

Organ system/finding	Causative factor for hypertension	Sequalae of hypertension
General	Poor growth, pallor; CKD	
	Edema	
	Obesity	
	Cushingoid features	
	Features of Turner, Willian, Marfan, Klippel-Trenaunay-Weber, Feuerstein-Mims, von Hippel-Lindau and multiple endocrine neoplasia syndromes	
Skin	Rash; SLE, vasculitis	
	Neurofibromas, axillary freckling	
	Acanthosis nigricans	
	Pseudoxanthoma elasticum	
	Congenital adrenal hyperplasia	
Eye	Cataract; corticosteroids	Hypertensive retinopathy
	Hemangioblastoma; von Hippel-Lindau	
	Proptosis; hyperthyroidism	
Abdomen	Mass; Wilms tumour, neuroblastoma, pheochromocytoma, recessive or dominant polycystic kidney disease, multicystic dysplastic kidney, obstructive uropathy and acute renal venous thrombosis.	
	Hepatosplenomegaly; recessive polycystic kidney disease	
Neurological		Cranial nerve palsy (particularly 3rd and 4th cranial nerves)
		Hemiparesis/other evidence of stroke
Cardiovascular	Cardiac murmur (coarctation, aortic stenosis)	LV enlargement, LVH
	Bruit over flanks (renal artery), abdomen, back, neck, and head	LV failure
	Weak femoral pulses, interscapular bruit (coarctation, mid-aortic syndrome)	
	Tachycardia (pheochromocytoma)	
Genitalia	Virilization (congenital adrenal hyperplasia)	

6.3 Investigation

Investigations include laboratory evaluation and Imaging studies.

6.3.1 Laboratory Evaluation

Laboratory Investigation is directed at determining the etiology of hypertension and identifying other CV risk factors and should include serum BUN, creatinine, electrolytes, lipid profile, urinalysis, for obese children, testing should also include haemoglobin A1c and alanine transaminase. If drug abuse is suspected, testing should also include drug screening. See table 11 for requires laboratory investigation and imagine studies.

6.3.2 Imaging Studies

- Kidney USG (KUB)
- Echocardiography – If pharmacologic antihypertensive therapy is being considered, an echocardiogram should be obtained to assess for left ventricular hypertrophy (LVH), which is the most prominent manifestation of end-organ damage from HTN

Table 11: Laboratory investigation and imaging studies

Laboratory tests	Comments
Routine laboratory tests to be performed in all children with hypertension	
Plasma creatinine, urea, electrolytes, and uric acid	
Fasting plasma glucose	
Plasma cholesterol (total, HDL and LDL) and triglycerides	
Urinalysis and culture	Microscopy for red cell casts indicative of glomerular disease; white cell casts indicative of interstitial disease
Quantification of albuminuria (albumin: creatinine ratio) proteinuria (protein: creatinine ratio)	

Echocardiography	
Renal ultrasonography (KUB)	
Additional laboratory tests in specific circumstances	
PRA and aldosterone	Renovascular hypertension (high PRA), primary hyperaldosteronism (PRA is very low in mineralocorticoid-related diseases and there may be associated hypokalaemia)
Urine and plasma catecholamines or metanephrines	Pheochromocytoma, extra-adrenal catecholamine producing tumours
Urinary free cortisol	Cushing syndrome
Urinary steroid profiles and more complex endocrine investigations	
Plasma cortisol, ACTH, 24 h urinary free cortisol	
Molecular genetic studies e.g., apparent mineralocorticoid excess, Liddle syndrome, glucocorticoid-remediable aldosteronism, hypertensive forms of congenital adrenal hyperplasia (113-hydroxylase deficiency, 17a-hydroxylase deficiency, neurofibromatosis, von Hippel-Lindau, and multiple endocrine neoplasia syndromes)	*Monogenic causes of hypertension (suspect where low renin hypertension and family history of early onset severe hypertension/death from cerebrovascular events and refractory hypertension)
Thyroid function tests: FT4 and TSH	Thyrotoxicosis
Plasma deoxycorticosterone and corticosterone, 18-hydroxycorticosterone, 18-hydroxy deoxycorticosterone and 11 deoxy cortisol	Congenital adrenal hyperplasia
Drug levels	Identify drugs that may cause hypertension. E.g., Amphetamines and ecstasy.

ACTH: Adrenocorticotropic Hormone

FT4: Thyroxine

PRA: Plasma Renin Activity

TSH: Thyroid-Stimulating Hormone

6.3.3. Further evaluation for underlying causes

If the history, physical examination, and initial laboratory evaluation suggest a secondary cause of HTN, further evaluation to determine the underlying etiology may be warranted. Depending on the results of the initial evaluation, this may include renal imaging studies (eg, renal scans or arteriogram), measurement of plasma renin, aldosterone, and plasma and urine catecholamines and sleep studies.

7. TREATMENT

7.1 None emergent treatment of hypertension in children and adolescents

Treatment for chronic hypertension (HTN) includes both nonpharmacologic and pharmacologic interventions. Management decisions are dependent upon the severity of HTN as in table 1 above, the underlying cause, the presence of other cardiovascular disease (CVD) risk factors, and defining target blood pressure (BP) goals, which are consistent with the American Academy of Paediatrics (AAP) guidelines or European Society of Hypertension guidelines.

7.2 Target BP goal

For children diagnosed with HTN and treated with nonpharmacologic and/or pharmacologic therapy, the target BP goal is a reduction of systolic and diastolic BP below the 90th percentile or <130/85 in adolescents (16 years or older). A lower goal is used for children who have CKD.

7.3 Non pharmacologic therapy

Nonpharmacologic therapy is provided for all children with elevated BP and any stage of HTN. This consists of weight reduction for children who are overweight, regular exercise restriction of sedentary activity, dietary salt restriction, and prevention of other CVD risk factors like dyslipidemia, vaping and smoking. See table 12 for activity recommendations for cardiovascular health from expert panel.

Table 12: Activity recommendations for cardiovascular health from the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents.

Age	Activity Recommendations
0-12 Months	Parents should create an environment promoting and modelling physical activity and limiting sedentary time
	Supportive actions: - Discourage TV/Screen time viewing altogether
1 to 4 years	Unlimited active playtime in safe, supportive environment
	Limit sedentary time, especially TV/Screen time/video
	Supportive actions: - For children <2 years, discourage TV/screen time viewing altogether - Limit total media time to no more than 1 to 2 hours of quality programming per day - No TV/Screen in child's bedroom - Encourage family activity at least once per week - Counsel routine activity for parents as role models for children
5 to 10 years	Moderate to vigorous physical activity* every day
	Limit daily leisure screen time (TV/screen time/video/computer)
	Supportive actions: - Prescribe moderate to vigorous activity* 1 hour/day with vigorous intensity physical activity^ on 3 days/week - Limit total media time to no more than 1 to 2 hours of quality programming per day - No TV in child's bedroom - Take activity and screen time history from child once a year

	- Match physical activity recommendations with energy intake - Recommend appropriate safety equipment relative to each sport - Support recommendations for daily physical education in schools
11 to 17 years	Moderate to vigorous physical activity* every day
	Limit leisure time TV/Screen time/video/computer use
	Supportive actions: - Encourage adolescents to aim for 1 hour/day of moderate to vigorous daily activity, with vigorous intense physical activity^ on 3 days/week - Encourage no TV/screen in bedroom - Limit total media time to no more than 1 to 2 hours of quality programming per day - Match activity recommendations with energy intake - Take activity and screen time history from adolescent at health supervision visits - Encourage involvement in year-round, physical activities - Support continued family activity once a week and/or family support of adolescent's physical activity program - Endorse appropriate safety equipment relative to each sport
18 to 21 years	Moderate to vigorous physical activity* every day
	Limit leisure time TV/Screen time/video/computer
	Supportive actions: - Support goal of 1 hour/day of moderate to vigorous daily activity with vigorous intense physical activity on 3 days/week - Recommend that combined leisure screen time not exceed 2 hours/day - Activity and screen time history at health supervision visits - Encourage involvement in year-round, lifelong physical activities

** Examples of moderate to vigorous physical activities are brisk walking, jogging or playing handball, tennis doubles).*

^ Examples of vigorous physical activities are running (5mph), swimming, playing singles tennis, playing football and jumping rope.

7.4 Pharmacologic therapy

For children with elevated BP, there is no need to initially administer pharmacologic therapy and only continue nonpharmacologic therapy.

For asymptomatic children with stage 1 HTN, there is no need to initially administer pharmacologic therapy and continue only to provide nonpharmacologic therapy to lower BP to target goals. Pharmacologic therapy is considered if BP target goals are not met after six months of nonpharmacologic therapy

For children with stage 1 HTN who are symptomatic or have evidence of end-organ target damage (eg, left ventricular hypertrophy), administer pharmacologic therapy in addition to nonpharmacologic therapy versus only nonpharmacologic therapy to reach target BP goals

For children with stage 2 HTN, management includes both pharmacologic and nonpharmacologic therapy. Children with neurologic symptoms should be evaluated and treated emergently.

For children with CKD, both nonpharmacologic and pharmacologic therapy is provided for any child with elevated BP or HTN.

For children with diabetes mellitus (DM) both nonpharmacologic and pharmacologic therapy is provided for any child with any stage of HTN.

7.5 Choice of antihypertensive agent

Data comparing antihypertensive drugs in children are lacking and hence it is not possible to make an evidence-based choice. Recommendations on the choice of agent for initial therapy are based upon the underlying cause of HTN, concurrent disorders, and the preference and experience of the responsible clinician.

In general, a single agent is first administered and a second agent from a different class is only added when initial drug dose reaches the highest recommended level or if the patient begins to experience side effects from the initial drug. Thiazide diuretic is the most commonly used second antihypertensive agent. The following classes of antihypertensive agents are used initially based on the clinical context (see Table 13)

Table 13: Antihypertensive medications for use in children and young adults.

Class of drug	Drug	Recommended starting dose (per day)	Maximal dose (per day)	Dosing interval
Diuretics	Amiloride	0.4-0.6 mg/kg	20 mg	Daily
	Chlortalidone	0.3 mg/kg	2 mg/kg up to 50 mg	Daily
	Furosemide	0.5-2 mg/kg	6 mg/kg	Daily-twice daily
	Hydrochlorothiazide	0.5-1 mg/kg	3 mg/kg/day	Daily
	Spironolactone	1 mg/kg	3.3 mg/kg up to 100 mg	Daily-twice daily
	Eplerenone	25 mg	100 mg	Daily-twice daily
	Triamterene	1-2 mg/kg	3-4 mg/kg up to 300 mg	Twice daily
Beta blockers	Atenolol	0.5-1 mg/kg	2 mg/kg up to 100 mg	Daily-twice daily
	Metoprolol	0.5-1 mg/kg	2 mg/kg	Daily-twice daily
	Propranolol	1 mg/kg	4 mg/kg up to 640 mg	Twice-thrice daily

Calcium channel blockers	Amlodipine	0.06-0.3 mg/kg	5-10 mg	Daily
	Felodipine	2.5 mg	10 mg	Daily
	Nifedipine (extended-release form)	0.25-0.5 mg/kg	3 mg/kg up to 120 mg	Daily-twice daily
ACE inhibitors	Benazepril	0.2 mg/kg up to 10 mg	0.6 mg/kg up to 40 mg	Daily
	Captopril	0.3-0.5 mg/kg/dose	6 mg/kg	Twice-thrice daily
	Enalapril	0.08-0.6 mg/kg		Daily
	Fosinopril	0.1-0.6 mg/kg	40 mg	Daily
	Lisinopril	0.08-0.6 mg/kg	0.6 mg/kg up to 40 mg	Daily
	Ramipril	1.5-6 mg/		Daily
ARBs	Candesartan	0. 16-0.5 mg/kg		Daily
	Irbesartan	75-150 mg	300 mg	Daily
	Losartan	0.7 mg/kg up to 50 mg	1.4 mg/kg up to 100 mg	Daily-twice daily
	Valsartan	0.4 mg/kg	40-80 mg	Daily
Alpha and beta blocker	Labetalol	1-3 mg/kg	10-12 mg/kg up to 1200 mg	Twice daily
Central alpha-agonist	Clonidine	0.2 mg/kg	2.4 mg	Twice daily
Peripheral alpha-blockers	Doxazosin	1 mg	4 mg	Daily
	Prazosin	0.05-0.1 mg/kg	0.5 mg/kg	Thrice daily
Vasodilators	Hydralazine	0.75 mg/kg	7.5 mg/kg up to 200 mg	Four times daily
	Minoxidil	0.2 mg/kg	50- 100 mg/day	Twice-thrice daily

Primary hypertension

Angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), or calcium channel blockers (CCBs).

Renal vascular disease

CCB rather than ACE inhibitor or ARB because of concerns of a reduction in glomerular filtration rate with ACE inhibitors and ARBs.

Chronic kidney disease

ACE inhibitor or ARB as data suggest that these agents slow the progression of CKD but close monitoring of kidney function is required.

Diabetes mellitus

ACE inhibitor or ARB as data suggest that these agents slow the progression of diabetic nephropathy.

Sexually active females

CCB as ACE inhibitors and ARBs are **contraindicated** in pregnancy because of known teratogenic adverse effects.

8. FOLLOW-UP

Continued physical follow-up is required to monitor the response to pharmacotherapy, detect any drug-related adverse effect and make dosing changes or introduce additional agents to achieve target BP goal.

9. SPORTS PARTICIPATION

The level of sports participation is based on the degree of BP elevation and evidence of end-organ damage.

10. APPROACH TO HYPERTENSIVE EMERGENCIES AND URGENCIES IN CHILDREN

The definition of childhood hypertension is statistically defined based upon the normative distribution of blood pressure (BP) in normal-weight children and is stratified by sex, age, and height as in table 1 above and also the blood pressure levels by age and percentile of hight for boys and girls as in appendix 1.

Recognition of hypertension in neonates and infants also depends on comparison with standards. However, these BP measurements are adjusted for differing parameters than in children over one year of age: birth weight and post-conceptual age for neonates (as in figure 4 and 5), age and, to a limited extent, weight and length for the perinatal period up to one year of age.

Severe hypertension, or hypertensive crisis, has traditionally been divided into hypertensive emergencies (acute severe symptomatic elevation in BP with evidence of potentially life-threatening symptoms or target-organ damage (e.g., hypertensive encephalopathy, heart failure, or renal disease) and hypertensive urgencies (acute severe elevation in BP without life-threatening symptoms or evidence of acute target-organ damage). However, clinical judgment must be used to gauge the severity of hypertension and its potential for life-threatening end-organ damage that determines the timing and intensity of management.

Figure 4 Age-specific percentiles of BP measurements in boy-birth to 12 months

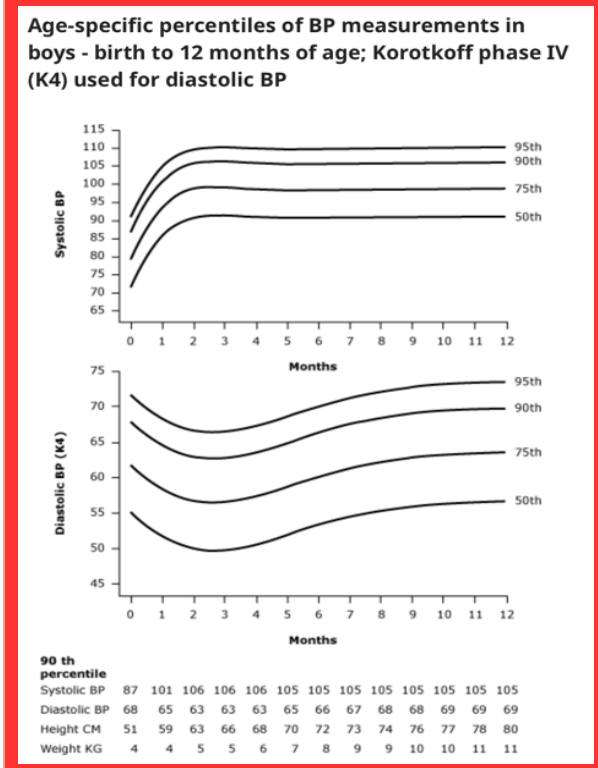
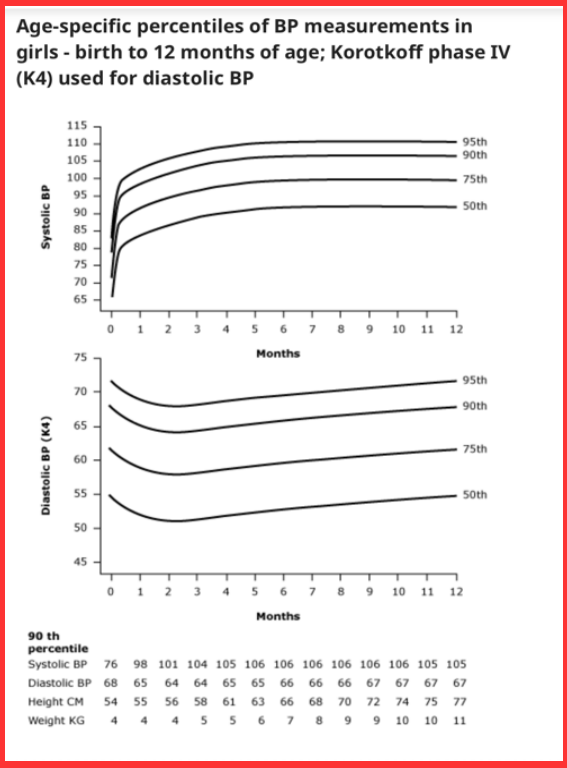


Figure 5: Age-specific percentiles of BP measurements in girls-birth to 12 months



11. HYPERTENSIVE EMERGENCY STABILIZATION

Paediatric patients should be referred to an immediate source of care (eg, emergency department) if they have serious symptoms and the BP value is at the stage 2 level as classified in table 1 above, or the BP is >30 mm Hg above the 95th percentile for children less than 16 years of age or >180/120 in an adolescent. Antihypertensive drugs for hypertensive disorders are summarized in table 14.

Table 14: Antihypertensive drugs for hypertensive emergencies and urgencies

Drug	Class	Route	Dose	Onset of Action	Comment
Sodium nitroprusside	Direct vasodilator	Intravenous infusion	0.5-8 µg/kg per min	Within seconds	May cause thiocyanate toxicity, inactivated by light
Nitro-glycerine	Direct vasodilator	Intravenous infusion	0.1-2 µg/kg per min	1-2 min	May cause methemoglobinemia, vasodilating effect primarily on the venous side - efficient in heart failure, limited efficacy in children
Labetalol	Alpha and beta blocker	Intravenous infusion	0.25-3 mg/kg per hr	5-10 min	Contraindication in asthma, heart failure and may cause bradycardia
Nicardipine	Calcium channel blocker	Intravenous infusion	1-3 µg/kg per min	Within minutes	Reflex tachycardia
Clonidine	Central alpha-agonist	Intravenous bolus	2-6 µg/kg per dose	10 min	Dry mouth, sedation and rebound hypertension
Esmolol	Beta-blocker	Intravenous infusion	100-500 µg/kg per min	Within seconds	Contraindication in asthma, may cause bradycardia
Enalaprilat	ACEI	Intravenous bolus	0.005-0.01 mg/kg per dose	15 min	Contraindication in suspected bilateral renal artery stenosis
Furosemide	Loop diuretic	Intravenous bolus	0.5-5 mg/kg per dose	Within minutes	Hypokalaemia. Useful in volume hypertension
Urapidil	Peripheral alpha blocker and central agonist of 5-HT1A receptors	Intravenous infusion	Initial dose: 0.5-4.0 mg/kg per hr Maintenance dose:	1-5 min	May cause sedation, palpitation and nausea

			0.2-2.0 mg/kg per hr		
Nifedipine	Calcium channel blocker	Orally	0.25 mg/kg per dose	20-30 min	May cause unpredictable hypotension, reflex tachycardia
Isradipine	Calcium channel blocker (L-type)	Orally	0.05-0.1 mg/kg per dose	1 hr	Higher doses may cause blood pressure drop of >25%
Captopril	ACEI	Orally	0.1-0.2 mg/kg per dose	10-20 min	Contraindication in suspected bilateral renal artery stenosis
Minoxidil	Direct vasodilator	Orally	0.1-0.2 mg/kg per dose	5-10 min	Fluid retention

11.1 Initial management of these patients includes:

5 Support airway, breathing, and circulation

6 Simultaneous with stabilization, confirm BP elevation

7 Determine if signs of end-organ damage are present

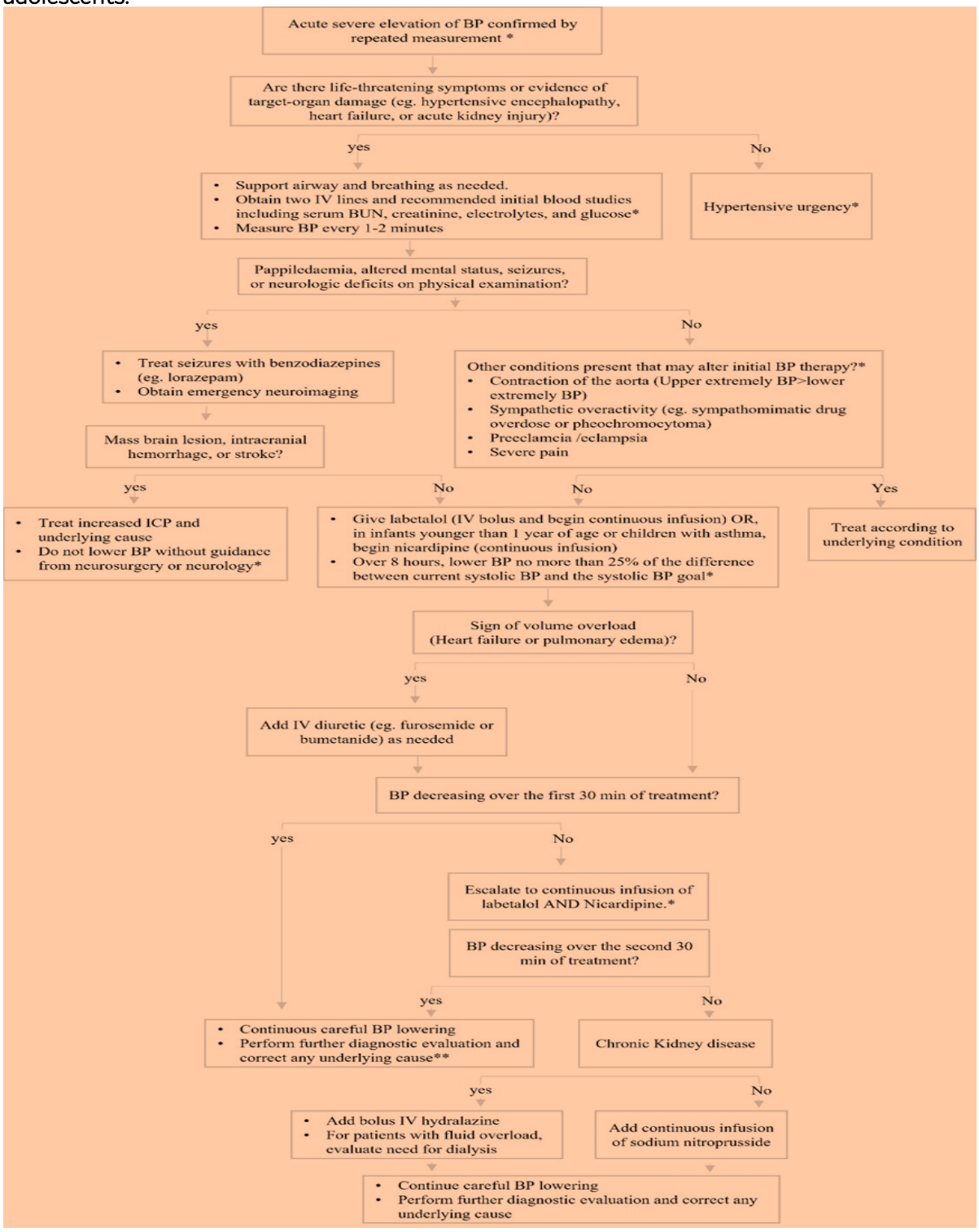
8 Identify conditions that alter BP management

11.2 Initial treatment

Treatment of hypertensive emergencies and urgencies in children is described in the algorithms.

Details of initial management of hypertensive emergencies are described in Figure 6 and 7.

Figure 6: algorithm for Initial management of hypertensive emergencies in children and adolescents.



Whenever possible, obtain an emergency consultation with a paediatric nephrologist, paediatric cardiologist or intensivist guide management decisions. For recommended antihypertensive and

diuretic drug dosing, refer to Table 14 on antihypertensive drugs on hypertensive emergencies and urgencies.

BP: Blood Pressure; IV: Intravenous; BUN: Blood Urea Nitrogen; ICP: Intracranial Pressure.

** Typically, BP is >30 mmHg above the 95th percentile for age, sex, and height. The absolute level of BP elevation is less important than whether symptoms of end-organ damage are present. Auscultation is the preferred method during repeat measurement; appropriate cuff size and placement should be ensured.*

¶ In addition to initial blood studies, all children with severe hypertension should undergo evaluation of a urinalysis with microscopy, electrocardiogram, echocardiogram, and chest radiograph; selected patients may warrant a urine toxicology screen or a urine pregnancy test. Obtaining these studies should not interfere with initial stabilization and treatment of a hypertensive emergency.

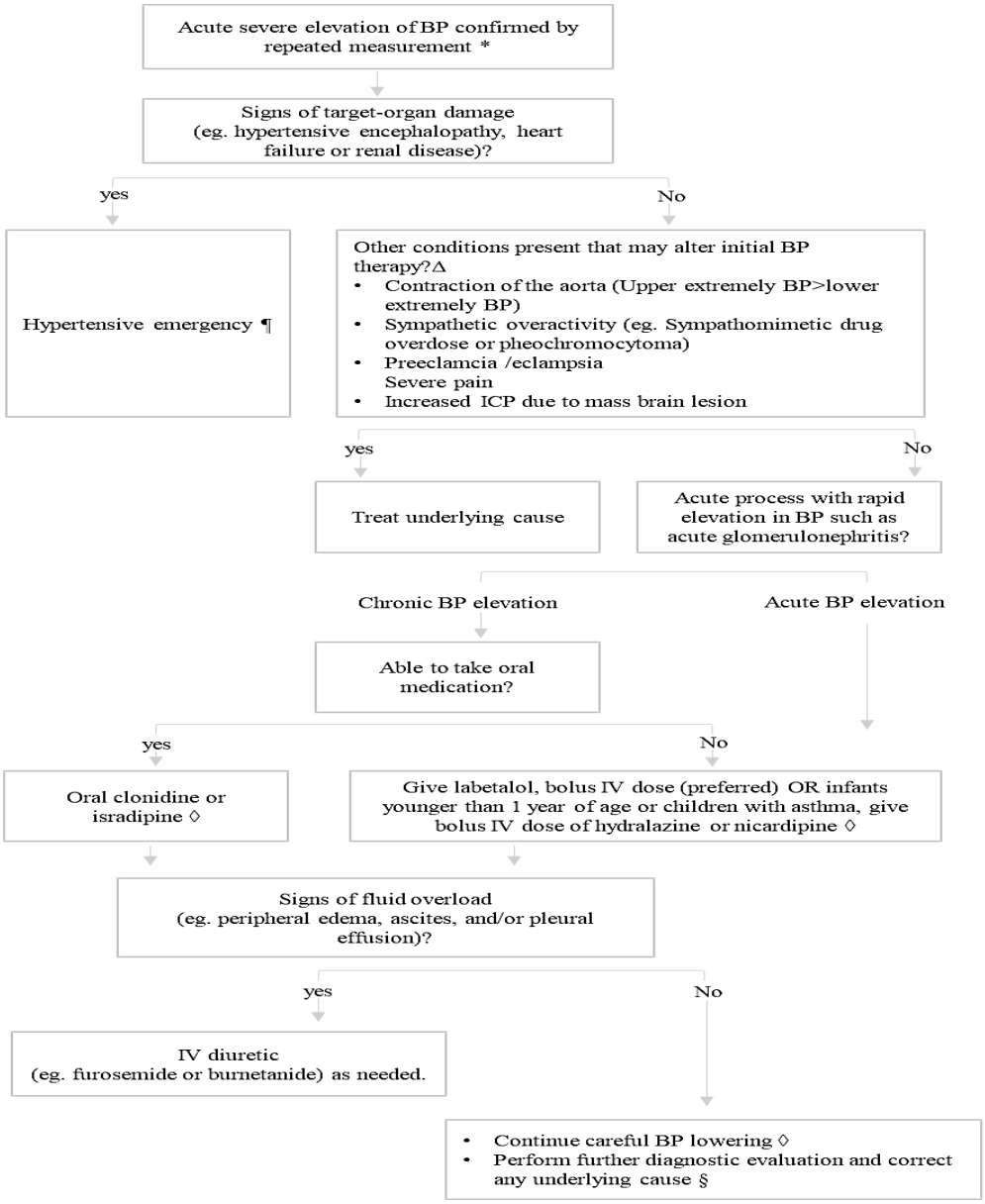
Δ Use automatic or auscultatory BP measurements until intra-arterial BP measurement can be obtained. Antihypertensive treatment should not be delayed to obtain intra-arterial access.

‡ The typical systolic BP goal is 95th percentile for age, sex, and height.

† For patients with contraindications to labetalol, proceed to either continuous infusion of sodium nitroprusside or, in patients with chronic renal disease, IV bolus hydralazine. There is a wide range of dosing for continuous IV infusion of labetalol or nicardipine. In general, the clinician should start with the lowest dose of the range and adjust the infusion rate based upon BP response.

** Refer to table 8 on causes of secondary hypertension in children and adolescents.

Figure 7: Initial management of hypertensive urgencies in children and adolescents.



Whenever possible, obtain urgent consultation with a paediatric nephrologist or intensivist to help guide management decisions. For antihypertensive and diuretic drug dosing, refer to table 16 on management of hypertensive emergencies and management of edema in children and adolescents.

BP: Blood Pressure; ICP: Intracranial Pressure; IV: Intravenous.

** Typically, BP is >30 mmHg above the 95th percentile for age, sex, and height. The absolute level of BP elevation is less important than whether symptoms of end-organ damage are present. Auscultation is the preferred method during repeat measurement; appropriate cuff size and placement should be ensured.*

¶ Refer to Figure 6 on management of hypertensive emergencies in children.

◊ The treatment goal for children with hypertensive urgencies depends upon the clinical situation. The ultimate goal would be a systolic BP <90 percentile for age, sex, and height in children <13 years of age or <130/80 in adolescents ≥13 years of age. However, a higher goal such as the 95th percentile may be appropriate initially.

Patients with an acute BP elevation warrant urgent treatment to the systolic goal BP over several hours. For children with chronic hypertension due to a known condition (eg, chronic kidney disease) in which BP has increased gradually over time, lowering of the BP should occur less quickly (eg, over 1 to 2 days or more).

12. FURTHER EVALUATION

After initial stabilization and treatment, further evaluation consists of a complete history, physical examination, and ancillary studies to identify the underlying etiology as mentioned in section 6 of this guideline.

Etiology

The etiology of paediatric hypertensive emergencies and urgencies varies significantly by age and largely parallels underlying causes of hypertension.

13. REFERENCES

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Annex 1: Blood pressure levels by age and percentile of height for boys

BP Percentile	Systolic BP (mm Hg)							Diastolic BP (mm Hg)						
	Height Percentile or Measured Height							Height Percentile or Measured Height						
	5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1 year														
Height (in)	30.4	30.8	31.6	32.4	33.3	34.1	34.6	30.4	30.8	31.6	32.4	33.3	34.1	34.6
Height (cm)	77.2	78.3	80.2	82.4	84.6	86.7	87.9	77.2	78.3	80.2	82.4	84.6	86.7	87.9
50th	85	85	86	86	87	88	88	40	40	40	41	41	42	42
90th	98	99	99	100	100	101	101	52	52	53	53	54	54	54
95th	102	102	103	103	104	105	105	54	54	55	55	56	57	57
95th + 12 mm Hg	114	114	115	115	116	117	117	66	66	67	67	68	69	69
2 years														
Height (in)	33.9	34.4	35.3	36.3	37.3	38.2	38.8	33.9	34.4	35.3	36.3	37.3	38.2	38.8
Height (cm)	86.1	87.4	89.6	92.1	94.7	97.1	98.5	86.1	87.4	89.6	92.1	94.7	97.1	98.5

50th	87	87	88	89	89	90	91	43	43	44	44	45	46	46
90th	100	100	101	102	103	103	104	55	55	56	56	57	58	58
95th	104	105	105	106	107	107	108	57	58	58	59	60	61	61
95th + 12 mm Hg	116	117	117	118	119	119	120	69	70	70	71	72	73	73
3 years														
Height (in)	36.4	37	37.9	39	40.1	41.1	41.7	36.4	37	37.9	39	40.1	41.1	41.7
Height (cm)	92.5	93.9	96.3	99	101.8	104.3	105.8	92.5	93.9	96.3	99	101.8	104.3	105.8
50th	88	89	89	90	91	92	92	45	46	46	47	48	49	49
90th	101	102	102	103	104	105	105	58	58	59	59	60	61	61
95th	106	106	107	107	108	109	109	60	61	61	62	63	64	64
95th + 12 mm Hg	118	118	119	119	120	121	121	72	73	73	74	75	76	76
4 years														
Height (in)	38.8	39.4	40.5	41.7	42.9	43.9	44.5	38.8	39.4	40.5	41.7	42.9	43.9	44.5
Height (cm)	98.5	100.2	102.9	105.9	108.9	111.5	113.2	98.5	100.2	102.9	105.9	108.9	111.5	113.2

50th	90	90	91	92	93	94	94	48	49	49	50	51	52	52
90th	102	103	104	105	105	106	107	60	61	62	62	63	64	64
95th	107	107	108	108	109	110	110	63	64	65	66	67	67	68
95th + 12 mm Hg	119	119	120	120	121	122	122	75	76	77	78	79	79	80
5 years														
Height (in)	41.1	41.8	43	44.3	45.5	46.7	47.4	41.1	41.8	43	44.3	45.5	46.7	47.4
Height (cm)	104.4	106.2	109.1	112.4	115.7	118.6	120.3	104.4	106.2	109.1	112.4	115.7	118.6	120.3
50th	91	92	93	94	95	96	96	51	51	52	53	54	55	55
90th	103	104	105	106	107	108	108	63	64	65	65	66	67	67
95th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
95th + 12 mm Hg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
6 years														
Height (in)	43.4	44.2	45.4	46.8	48.2	49.4	50.2	43.4	44.2	45.4	46.8	48.2	49.4	50.2
Height (cm)	110.3	112.2	115.3	118.9	122.4	125.6	127.5	110.3	112.2	115.3	118.9	122.4	125.6	127.5

50th	93	93	94	95	96	97	98	54	54	55	56	57	57	58
90th	105	105	106	107	109	110	110	66	66	67	68	68	69	69
95th	108	109	110	111	112	113	114	69	70	70	71	72	72	73
95th + 12 mm Hg	120	121	122	123	124	125	126	81	82	82	83	84	84	85
7 years														
Height (in)	45.7	46.5	47.8	49.3	50.8	52.1	52.9	45.7	46.5	47.8	49.3	50.8	52.1	52.9
Height (cm)	116.1	118	121.4	125.1	128.9	132.4	134.5	116.1	118	121.4	125.1	128.9	132.4	134.5
50th	94	94	95	97	98	98	99	56	56	57	58	58	59	59
90th	106	107	108	109	110	111	111	68	68	69	70	70	71	71
95th	110	110	111	112	114	115	116	71	71	72	73	73	74	74
95th + 12 mm Hg	122	122	123	124	126	127	128	83	83	84	85	85	86	86
8 years														
Height (in)	47.8	48.6	50	51.6	53.2	54.6	55.5	47.8	48.6	50	51.6	53.2	54.6	55.5
Height (cm)	121.4	123.5	127	131	135.1	138.8	141	121.4	123.5	127	131	135.1	138.8	141

50th	95	96	97	98	99	99	100	57	57	58	59	59	60	60
90th	107	108	109	110	111	112	112	69	70	70	71	72	72	73
95th	111	112	112	114	115	116	117	72	73	73	74	75	75	75
95th + 12 mm Hg	123	124	124	126	127	128	129	84	85	85	86	87	87	87
9 years														
Height (in)	49.6	50.5	52	53.7	55.4	56.9	57.9	49.6	50.5	52	53.7	55.4	56.9	57.9
Height (cm)	126	128.3	132.1	136.3	140.7	144.7	147.1	126	128.3	132.1	136.3	140.7	144.7	147.1
50th	96	97	98	99	100	101	101	57	58	59	60	61	62	62
90th	107	108	109	110	112	113	114	70	71	72	73	74	74	74
95th	112	112	113	115	116	118	119	74	74	75	76	76	77	77
95th + 12 mm Hg	124	124	125	127	128	130	131	86	86	87	88	88	89	89
10 years														
Height (in)	51.3	52.2	53.8	55.6	57.4	59.1	60.1	51.3	52.2	53.8	55.6	57.4	59.1	60.1
Height (cm)	130.2	132.7	136.7	141.3	145.9	150.1	152.7	130.2	132.7	136.7	141.3	145.9	150.1	152.7

50th	97	98	99	100	101	102	103	59	60	61	62	63	63	64
90th	108	109	111	112	113	115	116	72	73	74	74	75	75	76
95th	112	113	114	116	118	120	121	76	76	77	77	78	78	78
95th + 12 mm Hg	124	125	126	128	130	132	133	88	88	89	89	90	90	90
11 years														
Height (in)	53	54	55.7	57.6	59.6	61.3	62.4	53	54	55.7	57.6	59.6	61.3	62.4
Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
50th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
90th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
95th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
95th + 12 mm Hg	126	126	128	130	132	135	136	89	90	90	90	90	90	90
12 years														
Height (in)	55.2	56.3	58.1	60.1	62.2	64	65.2	55.2	56.3	58.1	60.1	62.2	64	65.2
Height (cm)	140.3	143	147.5	152.7	157.9	162.6	165.5	140.3	143	147.5	152.7	157.9	162.6	165.5

50th	101	101	102	104	106	108	109	61	62	62	62	62	63	63
90th	113	114	115	117	119	121	122	75	75	75	75	75	76	76
95th	116	117	118	121	124	126	128	78	78	78	78	78	79	79
95th + 12 mm Hg	128	129	130	133	136	138	140	90	90	90	90	90	91	91
13 years														
Height (in)	57.9	59.1	61	63.1	65.2	67.1	68.3	57.9	59.1	61	63.1	65.2	67.1	68.3
Height (cm)	147	150	154.9	160.3	165.7	170.5	173.4	147	150	154.9	160.3	165.7	170.5	173.4
50th	103	104	105	108	110	111	112	61	60	61	62	63	64	65
90th	115	116	118	121	124	126	126	74	74	74	75	76	77	77
95th	119	120	122	125	128	130	131	78	78	78	78	80	81	81
95th + 12 mm Hg	131	132	134	137	140	142	143	90	90	90	90	92	93	93
14 years														
Height (in)	60.6	61.8	63.8	65.9	68	69.8	70.9	60.6	61.8	63.8	65.9	68	69.8	70.9
Height (cm)	153.8	156.9	162	167.5	172.7	177.4	180.1	153.8	156.9	162	167.5	172.7	177.4	180.1

50th	105	106	109	111	112	113	113	60	60	62	64	65	66	67
90th	119	120	123	126	127	128	129	74	74	75	77	78	79	80
95th	123	125	127	130	132	133	134	77	78	79	81	82	83	84
95th + 12 mm Hg	135	137	139	142	144	145	146	89	90	91	93	94	95	96
15 years														
Height (in)	62.6	63.8	65.7	67.8	69.8	71.5	72.5	62.6	63.8	65.7	67.8	69.8	71.5	72.5
Height (cm)	159	162	166.9	172.2	177.2	181.6	184.2	159	162	166.9	172.2	177.2	181.6	184.2
50th	108	110	112	113	114	114	114	61	62	64	65	66	67	68
90th	123	124	126	128	129	130	130	75	76	78	79	80	81	81
95th	127	129	131	132	134	135	135	78	79	81	83	84	85	85
95th + 12 mm Hg	139	141	143	144	146	147	147	90	91	93	95	96	97	97
16 years														
Height (in)	63.8	64.9	66.8	68.8	70.7	72.4	73.4	63.8	64.9	66.8	68.8	70.7	72.4	73.4
Height (cm)	162.1	165	169.6	174.6	179.5	183.8	186.4	162.1	165	169.6	174.6	179.5	183.8	186.4

50th	111	112	114	115	115	116	116	63	64	66	67	68	69	69
90th	126	127	128	129	131	131	132	77	78	79	80	81	82	82
95th	130	131	133	134	135	136	137	80	81	83	84	85	86	86
95th + 12 mm Hg	142	143	145	146	147	148	149	92	93	95	96	97	98	98
17 years														
Height (in)	64.5	65.5	67.3	69.2	71.1	72.8	73.8	64.5	65.5	67.3	69.2	71.1	72.8	73.8
Height (cm)	163.8	166.5	170.9	175.8	180.7	184.9	187.5	163.8	166.5	170.9	175.8	180.7	184.9	187.5
50th	114	115	116	117	117	118	118	65	66	67	68	69	70	70
90th	128	129	130	131	132	133	134	78	79	80	81	82	82	83
95th	132	133	134	135	137	138	138	81	82	84	85	86	86	87
95th + 12 mm Hg	144	145	146	147	149	150	150	93	94	96	97	98	98	99

Annex 2: Blood pressure levels by age and percentile of height for girls

BP Percentile	Systolic BP (mm Hg)							Diastolic BP (mm Hg)						
	Height Percentile or Measured Height							Height Percentile or Measured Height						
	5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1 year														
Height (in)	29.7	30.2	30.9	31.8	32.7	33.4	33.9	29.7	30.2	30.9	31.8	32.7	33.4	33.9
Height (cm)	75.4	76.6	78.6	80.8	83	84.9	86.1	75.4	76.6	78.6	80.8	83	84.9	86.1
50th	84	85	86	86	87	88	88	41	42	42	43	44	45	46
90th	98	99	99	100	101	102	102	54	55	56	56	57	58	58
95th	101	102	102	103	104	105	105	59	59	60	60	61	62	62
95th + 12 mm Hg	113	114	114	115	116	117	117	71	71	72	72	73	74	74
2 years														
Height (in)	33.4	34	34.9	35.9	36.9	37.8	38.4	33.4	34	34.9	35.9	36.9	37.8	38.4
Height (cm)	84.9	86.3	88.6	91.1	93.7	96	97.4	84.9	86.3	88.6	91.1	93.7	96	97.4
50th	87	87	88	89	90	91	91	45	46	47	48	49	50	51

90th	101	101	102	103	104	105	106	58	58	59	60	61	62	62
95th	104	105	106	106	107	108	109	62	63	63	64	65	66	66
95th + 12 mm Hg	116	117	118	118	119	120	121	74	75	75	76	77	78	78
3 years														
Height (in)	35.8	36.4	37.3	38.4	39.6	40.6	41.2	35.8	36.4	37.3	38.4	39.6	40.6	41.2
Height (cm)	91	92.4	94.9	97.6	100.5	103.1	104.6	91	92.4	94.9	97.6	100.5	103.1	104.6
50th	88	89	89	90	91	92	93	48	48	49	50	51	53	53
90th	102	103	104	104	105	106	107	60	61	61	62	63	64	65
95th	106	106	107	108	109	110	110	64	65	65	66	67	68	69
95th + 12 mm Hg	118	118	119	120	121	122	122	76	77	77	78	79	80	81
4 years														
Height (in)	38.3	38.9	39.9	41.1	42.4	43.5	44.2	38.3	38.9	39.9	41.1	42.4	43.5	44.2
Height (cm)	97.2	98.8	101.4	104.5	107.6	110.5	112.2	97.2	98.8	101.4	104.5	107.6	110.5	112.2
50th	89	90	91	92	93	94	94	50	51	51	53	54	55	55

90th	103	104	105	106	107	108	108	62	63	64	65	66	67	67
95th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
95th + 12 mm Hg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
5 years														
Height (in)	40.8	41.5	42.6	43.9	45.2	46.5	47.3	40.8	41.5	42.6	43.9	45.2	46.5	47.3
Height (cm)	103.6	105.3	108.2	111.5	114.9	118.1	120	103.6	105.3	108.2	111.5	114.9	118.1	120
50th	90	91	92	93	94	95	96	52	52	53	55	56	57	57
90th	104	105	106	107	108	109	110	64	65	66	67	68	69	70
95th	108	109	109	110	111	112	113	68	69	70	71	72	73	73
95th + 12 mm Hg	120	121	121	122	123	124	125	80	81	82	83	84	85	85
6 years														
Height (in)	43.3	44	45.2	46.6	48.1	49.4	50.3	43.3	44	45.2	46.6	48.1	49.4	50.3
Height (cm)	110	111.8	114.9	118.4	122.1	125.6	127.7	110	111.8	114.9	118.4	122.1	125.6	127.7
50th	92	92	93	94	96	97	97	54	54	55	56	57	58	59

90th	105	106	107	108	109	110	111	67	67	68	69	70	71	71
95th	109	109	110	111	112	113	114	70	71	72	72	73	74	74
95th + 12 mm Hg	121	121	122	123	124	125	126	82	83	84	84	85	86	86
7 years														
Height (in)	45.6	46.4	47.7	49.2	50.7	52.1	53	45.6	46.4	47.7	49.2	50.7	52.1	53
Height (cm)	115.9	117.8	121.1	124.9	128.8	132.5	134.7	115.9	117.8	121.1	124.9	128.8	132.5	134.7
50th	92	93	94	95	97	98	99	55	55	56	57	58	59	60
90th	106	106	107	109	110	111	112	68	68	69	70	71	72	72
95th	109	110	111	112	113	114	115	72	72	73	73	74	74	75
95th + 12 mm Hg	121	122	123	124	125	126	127	84	84	85	85	86	86	87
8 years														
Height (in)	47.6	48.4	49.8	51.4	53	54.5	55.5	47.6	48.4	49.8	51.4	53	54.5	55.5
Height (cm)	121	123	126.5	130.6	134.7	138.5	140.9	121	123	126.5	130.6	134.7	138.5	140.9
50th	93	94	95	97	98	99	100	56	56	57	59	60	61	61

90th	107	107	108	110	111	112	113	69	70	71	72	72	73	73
95th	110	111	112	113	115	116	117	72	73	74	74	75	75	75
95th + 12 mm Hg	122	123	124	125	127	128	129	84	85	86	86	87	87	87
9 years														
Height (in)	49.3	50.2	51.7	53.4	55.1	56.7	57.7	49.3	50.2	51.7	53.4	55.1	56.7	57.7
Height (cm)	125.3	127.6	131.3	135.6	140.1	144.1	146.6	125.3	127.6	131.3	135.6	140.1	144.1	146.6
50th	95	95	97	98	99	100	101	57	58	59	60	60	61	61
90th	108	108	109	111	112	113	114	71	71	72	73	73	73	73
95th	112	112	113	114	116	117	118	74	74	75	75	75	75	75
95th + 12 mm Hg	124	124	125	126	128	129	130	86	86	87	87	87	87	87
10 years														
Height (in)	51.1	52	53.7	55.5	57.4	59.1	60.2	51.1	52	53.7	55.5	57.4	59.1	60.2
Height (cm)	129.7	132.2	136.3	141	145.8	150.2	152.8	129.7	132.2	136.3	141	145.8	150.2	152.8
50th	96	97	98	99	101	102	103	58	59	59	60	61	61	62

90th	109	110	111	112	113	115	116	72	73	73	73	73	73	73
95th	113	114	114	116	117	119	120	75	75	76	76	76	76	76
95th + 12 mm Hg	125	126	126	128	129	131	132	87	87	88	88	88	88	88
11 years														
Height (in)	53.4	54.5	56.2	58.2	60.2	61.9	63	53.4	54.5	56.2	58.2	60.2	61.9	63
Height (cm)	135.6	138.3	142.8	147.8	152.8	157.3	160	135.6	138.3	142.8	147.8	152.8	157.3	160
50th	98	99	101	102	104	105	106	60	60	60	61	62	63	64
90th	111	112	113	114	116	118	120	74	74	74	74	74	75	75
95th	115	116	117	118	120	123	124	76	77	77	77	77	77	77
95th + 12 mm Hg	127	128	129	130	132	135	136	88	89	89	89	89	89	89
12 years														
Height (in)	56.2	57.3	59	60.9	62.8	64.5	65.5	56.2	57.3	59	60.9	62.8	64.5	65.5
Height (cm)	142.8	145.5	149.9	154.8	159.6	163.8	166.4	142.8	145.5	149.9	154.8	159.6	163.8	166.4
50th	102	102	104	105	107	108	108	61	61	61	62	64	65	65

90th	114	115	116	118	120	122	122	75	75	75	75	76	76	76
95th	118	119	120	122	124	125	126	78	78	78	78	79	79	79
95th + 12 mm Hg	130	131	132	134	136	137	138	90	90	90	90	91	91	91
13 years														
Height (in)	58.3	59.3	60.9	62.7	64.5	66.1	67	58.3	59.3	60.9	62.7	64.5	66.1	67
Height (cm)	148.1	150.6	154.7	159.2	163.7	167.8	170.2	148.1	150.6	154.7	159.2	163.7	167.8	170.2
50th	104	105	106	107	108	108	109	62	62	63	64	65	65	66
90th	116	117	119	121	122	123	123	75	75	75	76	76	76	76
95th	121	122	123	124	126	126	127	79	79	79	79	80	80	81
95th + 12 mm Hg	133	134	135	136	138	138	139	91	91	91	91	92	92	93
14 years														
Height (in)	59.3	60.2	61.8	63.5	65.2	66.8	67.7	59.3	60.2	61.8	63.5	65.2	66.8	67.7
Height (cm)	150.6	153	156.9	161.3	165.7	169.7	172.1	150.6	153	156.9	161.3	165.7	169.7	172.1
50th	105	106	107	108	109	109	109	63	63	64	65	66	66	66

90th	118	118	120	122	123	123	123	76	76	76	76	77	77	77
95th	123	123	124	125	126	127	127	80	80	80	80	81	81	82
95th + 12 mm Hg	135	135	136	137	138	139	139	92	92	92	92	93	93	94
15 years														
Height (in)	59.7	60.6	62.2	63.9	65.6	67.2	68.1	59.7	60.6	62.2	63.9	65.6	67.2	68.1
Height (cm)	151.7	154	157.9	162.3	166.7	170.6	173	151.7	154	157.9	162.3	166.7	170.6	173
50th	105	106	107	108	109	109	109	64	64	64	65	66	67	67
90th	118	119	121	122	123	123	124	76	76	76	77	77	78	78
95th	124	124	125	126	127	127	128	80	80	80	81	82	82	82
95th + 12 mm Hg	136	136	137	138	139	139	140	92	92	92	93	94	94	94
16 years														
Height (in)	59.9	60.8	62.4	64.1	65.8	67.3	68.3	59.9	60.8	62.4	64.1	65.8	67.3	68.3
Height (cm)	152.1	154.5	158.4	162.8	167.1	171.1	173.4	152.1	154.5	158.4	162.8	167.1	171.1	173.4
50th	106	107	108	109	109	110	110	64	64	65	66	66	67	67

90th	119	120	122	123	124	124	124	76	76	76	77	78	78	78
95th	124	125	125	127	127	128	128	80	80	80	81	82	82	82
95th + 12 mm Hg	136	137	137	139	139	140	140	92	92	92	93	94	94	94
17 years														
Height (in)	60	60.9	62.5	64.2	65.9	67.4	68.4	60	60.9	62.5	64.2	65.9	67.4	68.4
Height (cm)	152.4	154.7	158.7	163	167.4	171.3	173.7	152.4	154.7	158.7	163	167.4	171.3	173.7
50th	107	108	109	110	110	110	111	64	64	65	66	66	66	67
90th	120	121	123	124	124	125	125	76	76	77	77	78	78	78
95th	125	125	126	127	128	128	128	80	80	80	81	82	82	82
95th + 12 mm Hg	137	137	138	139	140	140	140	92	92	92	93	94	94	94