

HYPERTENSION

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HYPERTENSION

- Defined as persistent, nonphysiologic elevation of systemic blood pressure (BP).
- It is the most important modifiable risk factor for CHD, stroke, CHF, ESRD and peripheral vascular disease
- Globally, an estimated 26% of the world's population has HTN, and the prevalence is expected to increase to 29% by 2025.

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- Until age 45 years, a higher percentage of men than women have HTN; from age 45-64 years, the percentages are nearly equal. Beyond age 64 years, a higher percentage of women have HTN than men
 - Health care professionals must not only identify and treat patients with HTN but also promote a healthy lifestyle and preventive strategies to decrease the prevalence of HTN
 - Primary (formerly essential) hypertension accounts for 90-95% of adult cases.

SCREENING FOR HTN

- USPSTF recommends that all individuals 18 years or older should be screened for elevated BP .
- At a minimum, the frequency of screening should be as follows:
 - Adults with normal BP should have reassessment of their BP every year.
 - Adults should be screened at least semiannually (every 6 months) :
 - If they have risk factors for HTN (eg, obesity)
 - If their previously measured systolic BP was 120-129 (elevated BP)

DIAGNOSIS OF HTN

According to the American College of Cardiology/American Heart Association (ACC/AHA) 2017 report:

- Elevated BP at each of 2 or more office visits after an initial screening (3 readings at least 1 week apart) OR
- Initial presentation with hypertensive emergency or urgency (BP \geq 180/120 mmHg) OR
- Initial presentation with BP $>$ 160/100 in a patient with known target end-organ damage

Blood Pressure Categories



BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

STAGING HTN

- If there is a disparity in category between the systolic and diastolic pressures, the higher value determines the stage.
- Isolated systolic HTN : BP $\geq 130 / < 80$ mmHg
- Isolated diastolic HTN: BP $< 130 / \geq 80$ mmHg.

CONFIRMATION OF HTN DIAGNOSIS

- Mean daytime readings with ABPM $\geq 130/\geq 80$ mmHg
- Mean home BP readings measured with appropriate technique and with a device that has been validated in the office $\geq 130/\geq 80$
- Mean of serial office BP readings (in ≥ 3 occasions separated by at least 1 week) $\geq 130/\geq 80$ mmHg

Corresponding Values of Systolic BP/Diastolic BP for Clinic, Home (HBPM), Daytime, Nighttime, and 24-Hour Ambulatory (ABPM) Measurements.

Clinic	HBPM	Daytime ABPM	Nighttime ABPM	24-Hour ABPM
120/80	120/80	120/80	100/65	115/75
130/80	130/80	130/80	110/65	125/75
140/90	135/85	135/85	120/70	130/80
160/100	145/90	145/90	140/85	145/90

PRIMARY HTN

- The pathogenesis of primary HTN is most likely the result of numerous genetic and environmental factors that have multiple compounding effects on cardiovascular and renal structure and function.
- Risk factors:
 - Advancing age
 - Obesity and overweight
 - Family history: having 1 or 2 hypertensive patients doubles the risk of developing HTN
 - Race: HTN tends to be more common, be more severe, occur earlier in life, and be associated with greater target-organ damage in blacks.
 - Reduced nephron number: this may be related to genetic factors, intrauterine developmental disturbance (eg, hypoxia, drugs, nutritional deficiency), premature birth, and postnatal environment (eg, malnutrition, infections).
 - High-sodium diet : >3 g/day sodium chloride
 - Excessive alcohol consumption
 - Physical inactivity

SECONDARY HTN

- Renal causes
- Prescription or over-the-counter medications
- Illicit drug use , such as methamphetamines and cocaine .
- Primary aldosteronism .
- OSA
- Pheochromocytoma :About one-half of patients with pheochromocytoma have paroxysmal hypertension; most of the rest have what appears to be primary hypertension.
- Cushing's syndrome: HTN is a major cause of morbidity and death in patients with Cushing's syndrome.
- Other endocrine disorders like Hypothyroidism, hyperthyroidism, primary hyperparathyroidism & CAH
- Coarctation of the aorta :it is one of the major causes of secondary HTN in young children, but it may also be diagnosed in adulthood .

SECONDARY HTN/ RENAL CAUSES

- They are the most common (2.5-6%)
 - Primary renal disease : acute or chronic renal parenchymal (Polycystic kidney disease, CKD, Urinary tract obstruction)
 - Renovascular hypertension : due to fibromuscular dysplasia in younger patients and to atherosclerosis in older patients

PRESCRIPTION OR OTC MEDICATIONS

- OCPs (particularly those containing higher doses of estrogen)
- NSAIDs particularly chronic use
- Antidepressants including TCA, SSRIs and MAO inhibitors
- Corticosteroids, including both glucocorticoids and mineralocorticoids
- Decongestants, such as phenylephrine and pseudoephedrine
- Some weight-loss medications
- Sodium-containing antacids
- Erythropoietin
- Cyclosporine or tacrolimus
- Herbal remedies containing licorice

WHEN TO SCREEN FOR SECONDARY HTN?

- Drug-resistant or drug-induced HTN
- An acute rise in BP over a previously stable value
- Age of onset before puberty or <30 y, with no FHx of primary HTN or obesity
- Onset of diastolic HTN in older adults >65y
- Disproportionate TOD to the degree of HTN
- Unprovoked or excessive hypokalemia

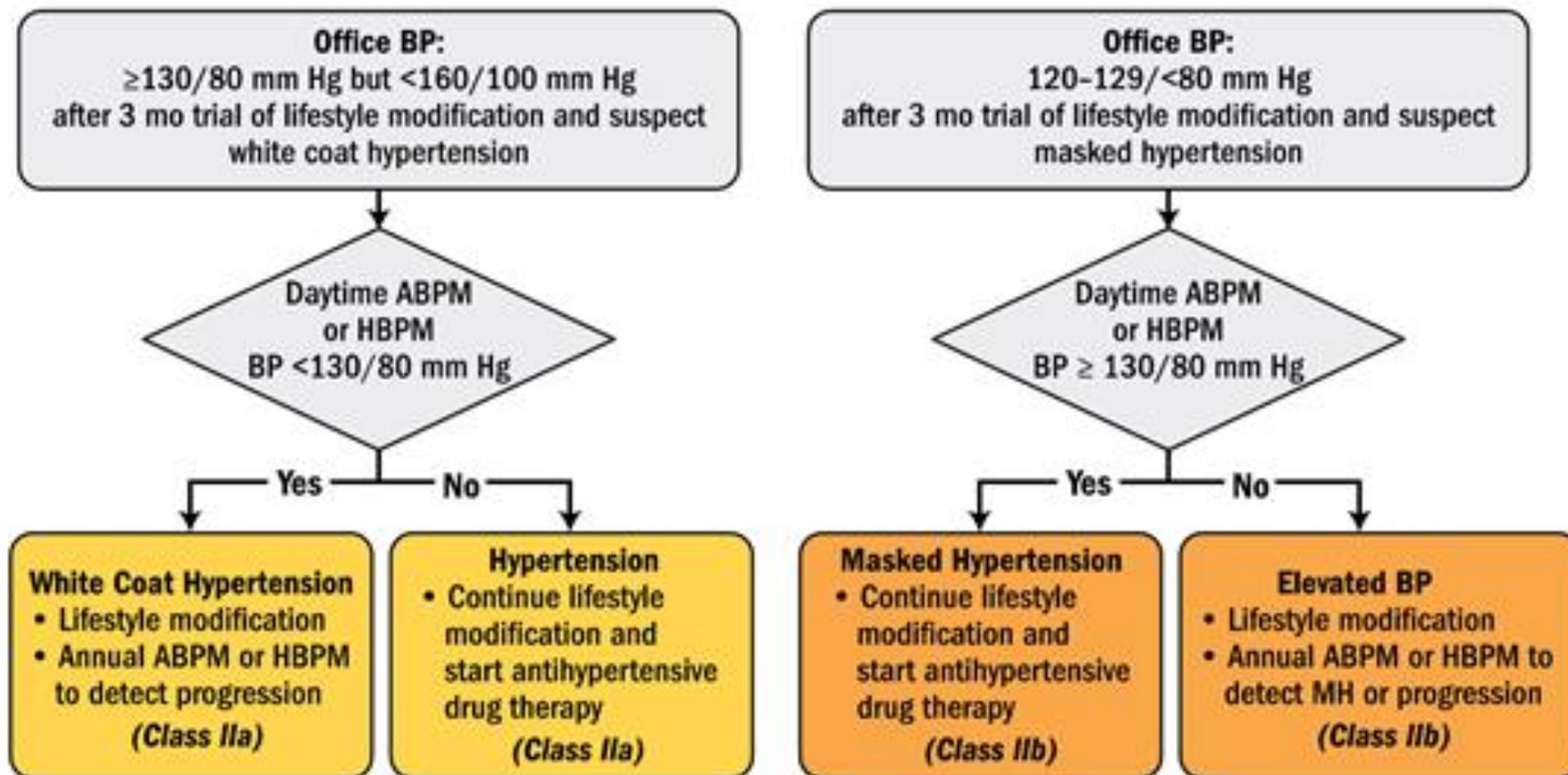
OTHER CATEGORIES

- White-Coat HTN: Office BP $\geq 130/\geq 80$ mmHg but an out-of-office BP (either mean daytime or mean home) $< 130/< 80$ mmHg
 - Prevalence 10-20%, more in children, older adults and women.
 - These patients should undergo reevaluation with out-of-office BP monitoring at least **annually** since these patients can develop HTN over time and can be at higher risk of CVD than normotensives.
- Masked HTN: Office BP $< 130/< 80$ mmHg but an out-of-office BP $\geq 130/\geq 80$ mmHg.
 - These patients should be treated the same as other patients with the diagnosis of HTN
 - Associated with an increased long-term risk of sustained HTN and increased risk of major adverse CV events and all-cause mortality, similar to that of sustained hypertension.

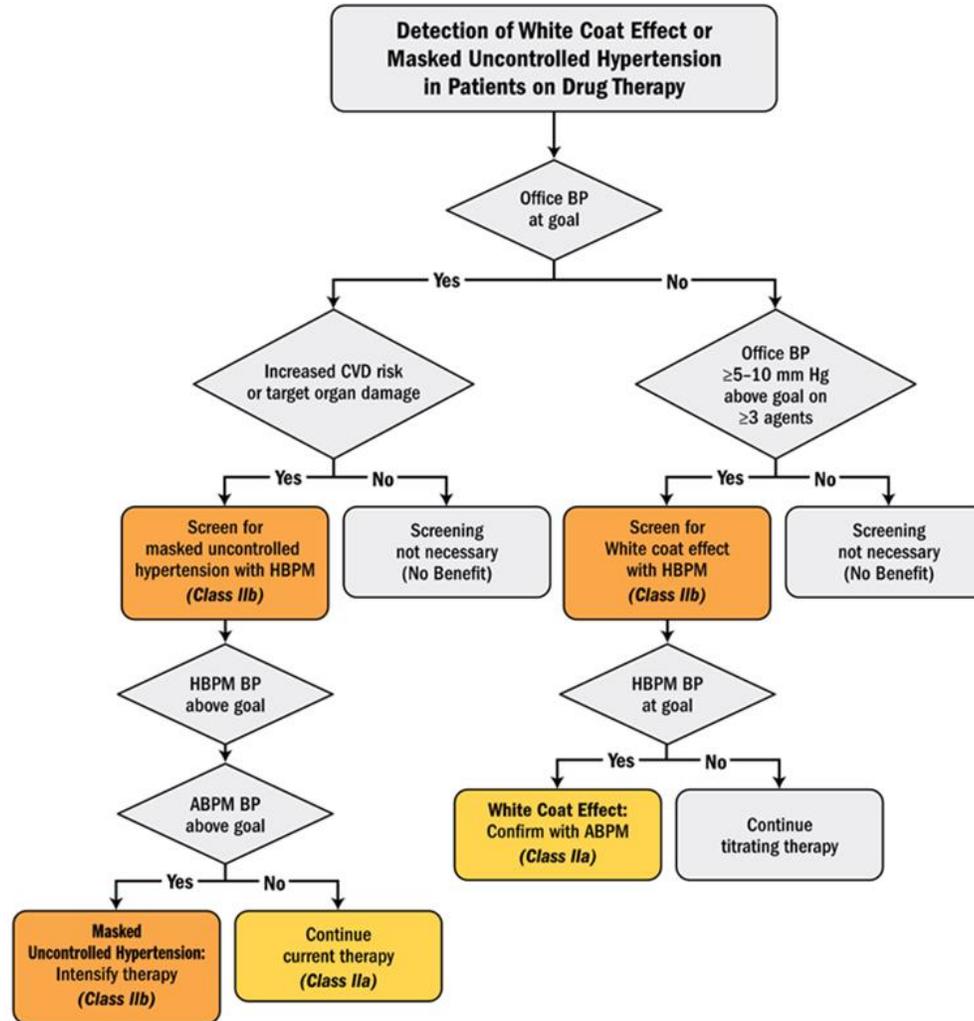
WHITE-COAT AND MASKED HTN CATEGORIES

	White-Coat HTN	Masked HTN
Office BP readings	$\geq 130/80$	$< 130/80$
Out-of-office BP readings	$< 130/80$	$\geq 130/80$
Pharmacological Treatment	Not indicated	Indicated
Risk of developing sustained HTN	Increased	Increased
CV risk	$>$ Normotensives, $<$ sustained HTN	= sustained HTN

Detection of White Coat Hypertension or Masked Hypertension in Patients Not on Drug Therapy



Detection of White Coat Hypertension or Masked Hypertension in Patients on Drug Therapy



Hypertension Categories

Clinic Blood Pressure
Elevated
Normal

White Coat Hypertension

Sustained Hypertension

Sustained Normotension

Masked Hypertension

Normal

Elevated

Ambulatory Blood Pressure

HTN CRISIS

- Hypertensive Emergency: SBP \geq 180 &/or DBP \geq 120 with TOD
- Hypertensive Urgency: SBP \geq 180 &/or DBP \geq 120 without TOD
- Mod-severe Hypertensive Retinopathy (formerly “malignant HTN”): a hypertensive emergency (BP \geq 180/120) characterized by :
 - Retinal hemorrhages, exudates, or papilledema, +/-
 - Hypertensive encephalopathy, +/-
 - Acute Hypertensive nephrosclerosis (formerly “malignant nephrosclerosis”)

APPROPRIATE BP MEASUREMENT

- BP should be measured in both arms:
 - Systolic BP readings in the left and right arms should be roughly equivalent.
 - A discrepancy of >15 mmHg may indicate subclavian stenosis and, hence, peripheral arterial disease and carries a higher risk of CVD and a significantly greater relative risk of cardiovascular death
- No caffeine 1 hr before and no smoking, food intake or strenuous exercise 30 min before measurement.
- Ideal cuff size:
 - Bladder length should be 80% of the arm circumference
 - Bladder width should be at least 40% of the arm circumference.

APPROPRIATE BP MEASUREMENT, CONT'D

- Inflate the BP cuff 20-30 mmHg above the estimated SBP (based on radial pulse disappearance)
 - To avoid the auscultatory gap.
 - To avoid the cuff inflation HTN in patients taking their BP using a sphygmomanometer.
- The systolic BP is marked by the 1st Korotkoff sound (1st sound heard).
- The diastolic BP is marked by the 5th korotkoff sound (complete sound disappearance) in adults, and the 4th Korotkoff (muffling) sound in children.

APPROPRIATE BP MEASUREMENT, CONT'D

- Check for postural hypotension in the following patients:
 - Over age 65 years
 - Those experiencing dizziness or weakness upon standing
 - Those with diabetes.
- Defined as ≥ 20 mmHg fall in systolic pressure &/or ≥ 10 mmHg fall in diastolic pressure upon rising from supine to an unassisted upright position.

EVALUATION OF HYPERTENSIVE PATIENTS

Focused History aiming to :

- Determine the extent of target-organ damage
- Assess other CV risk factors.
- Identify lifestyle factors that could potentially contribute to HTN.
- Identify interfering substances and potentially curable causes of secondary HTN.

TARGET ORGAN DAMAGE

- Heart : LVH, Angina or MI , Heart Failure.
- Brain: Stroke or TIA.
- Kidneys: CRF
- Blood vessels : Peripheral Arterial Disease.
- Eyes: Retinopathy

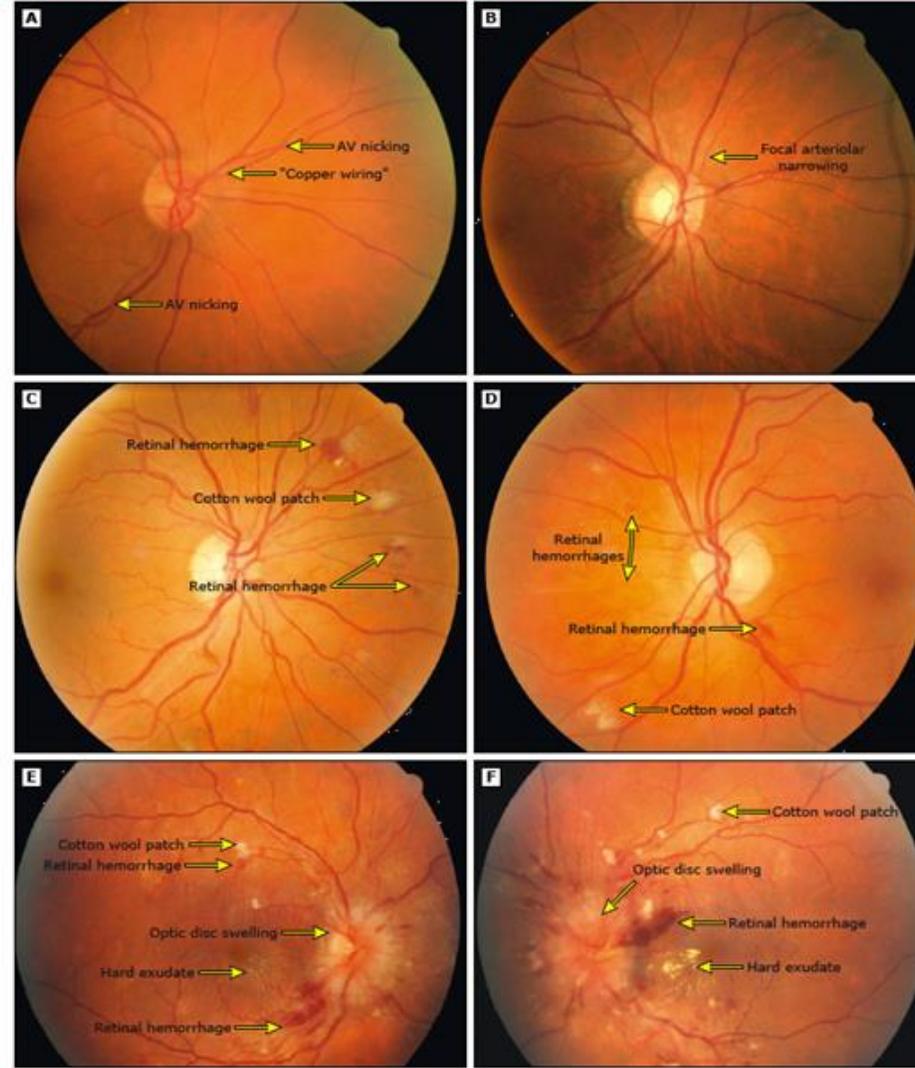
OTHER CVD RISK FACTORS

- Diabetes
- Hypercholesterolemia
- Obesity
- A family history of premature CVD or death (men <55, women < 65).
- Tobacco smoking and Alcohol
- CKD (eGFR<60 mL/min)
- Age (>45 for men, >55 for women)
- Physical Inactivity.

PHYSICAL EXAMINATION

- Body mass index (BMI)
- Funduscopic eye examination
 - Arteriovenous nicking,
 - Cotton-wool spots
 - Flame hemorrhages
 - Exudates
 - Papilledema associated with hypertensive emergencies
- Auscultate for carotid, abdominal, and femoral bruits
- Palpation of the thyroid gland

Retinal fundus photographs of hypertensive retinopathy



PHYSICAL EXAMINATION, CONT'D

- Chest Examination
 - Assess for signs of CHF, such as crackles or diminished breath sounds.
 - Assess the heart rate, rhythm, presence of murmurs, or an enlarged point of maximal impulse
- Abdominal Examination
 - Look for abdominal aortic pulsation, bruits, or masses.
- Lower Extremity Examination
 - Assess for the presence of PVD in the lower extremities such as diminished pulses, loss of extremity hair, thick toenails, cold or red skin, edema.
- Conduct a baseline neurologic assessment
 - Assess for neurologic changes from ischemic or hypertensive brain disease.

LABORATORY EVALUATION

BASIC TESTS

- Electrolytes: Na, Ca, K
- Serum creatinine (for eGFR)
- Fasting glucose
- FLP
- TSH
- Urine dipstick (for protein and glucose)
- ECG (rate, rhythm, evidence of ischemia or hypertrophy)

OPTIONAL TESTS

- Echocardiography
- Uric acid
- Urine albumin-to-creatinine ratio

HTN MANAGEMENT

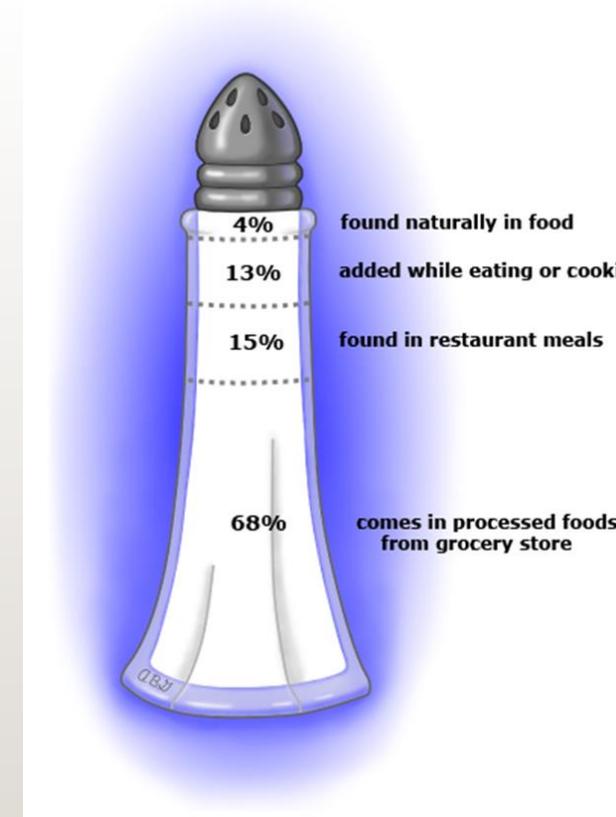
- Benefits of BP control:
 - 50 % relative risk reduction in the incidence of heart failure.
 - 30-40 % relative risk reduction in stroke.
 - 20-25 % relative risk reduction in MI.
- The goal of therapy is to lower BP to $<130/80$ in all hypertensive patients
- This can be achieved by pharmacological and nonpharmacological methods
- BP threshold to treat patients with medications is $130/80$ in all hypertensive patients except in patients with no known CVD **and** 10-year risk of CVD $<10\%$ (treat when BP $>140/90$)

Best Proven Nonpharmacologic Interventions for Prevention and Treatment of Hypertension*

	Nonpharmacologic Intervention	Dose	Approximate Impact on SBP	
			Hypertension	Normotension
Weight loss	Weight/body fat	Ideal body weight is best goal but at least 1 kg reduction in body weight for most adults who are overweight. Expect about 1 mm Hg for every 1 kg reduction in body weight.	-5 mm Hg	-2/3 mm Hg
Healthy diet	DASH dietary pattern	Diet rich in fruits, vegetables, whole grains, and low-fat dairy products with reduced content of saturated and trans fat	-11 mm Hg	-3 mm Hg
Reduced intake of dietary sodium	Dietary sodium	<1,500 mg/d is optimal goal but at least 1,000 mg/d reduction in most adults	-5/6 mm Hg	-2/3 mm Hg
Enhanced intake of dietary potassium	Dietary potassium	3,500–5,000 mg/d, preferably by consumption of a diet rich in potassium	-4/5 mm Hg	-2 mm Hg
Physical activity	Aerobic	<ul style="list-style-type: none"> • 120–150 min/wk • 65%–75% heart rate reserve 	-5/8 mm Hg	-2/4 mm Hg
	Dynamic Resistance	<ul style="list-style-type: none"> • 90–150 min/wk • 50%–80% 1 rep maximum • 6 exercises, 3 sets/exercise, 10 repetitions/set 	-4 mm Hg	-2 mm Hg
	Isometric Resistance	<ul style="list-style-type: none"> • 4 x 2 min (hand grip), 1 min rest between exercises, 30%–40% maximum voluntary contraction, 3 sessions/wk • 8–10 wk 	-5 mm Hg	-4 mm Hg
Moderation in alcohol intake	Alcohol consumption	In individuals who drink alcohol, reduce alcohol [†] to: <ul style="list-style-type: none"> • Men: ≤2 drinks daily • Women: ≤1 drink daily 	-4 mm Hg	-3 mm Hg

DIETARY MODIFICATIONS

- **DASH Diet (The dietary approaches to stop HTN)**
 - High in vegetables, fruits, low-fat dairy products, whole grains, poultry, fish, and nuts.
 - Low in sweets, sugar-sweetened beverages, and red meats.
 - Rich in potassium, magnesium, calcium, protein, and fiber.
 - Low in saturated fat, total fat, and cholesterol.
- **Sodium Restriction**
 - The main source of sodium in the diet is the salt added to packaged and processed foods and in foods from restaurants.
 - Optimally sodium should be restricted to <1500mg/day



PHARMACOLOGICAL TREATMENT

- Thiazide diuretics
- Long-acting CCB (dihydropyridine)
- ACE inhibitors
- ARBs

WHOM TO TREAT?

- When mean HBPM/daytime ABPM readings ≥ 135 mmHg systolic or ≥ 85 mmHg diastolic
- When average office BP $\geq 140/90$ mmHg
- When average office or mean HBPM or ABPM readings $> 130/80$ in the following:
 - Established CVD
 - 10-year CVD risk $> 10\%$
 - CKD
 - T2DM
 - Age > 65

GOAL BP

- For most patients on pharmacological treatment the goal BP is <130/80 (average office or HBPM readings)
- The goal can be <140/90 office readings or <135/85 HBPM readings in the following:
 - Patients with labile BP or postural hypotension
 - Patients with side effects to multiple antihypertensive medications
 - Patients already taking 3 antihypertensive medications (including a diuretic) at or near maximal antihypertensive doses
 - Patients 75 years or older with a high burden of comorbidity or a diastolic blood pressure <55 mmHg

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Hypertension Treatment

Compelling Indications	
Indication	Treatment Choice
Heart Failure	ACEI/ARB + BB + diuretic + spironolactone
Post-MI/Clinical CAD	ACEI/ARB AND BB
CAD	ACEI, BB, diuretic, CCB
Diabetes	ACEI/ARB, CCB, diuretic
CKD	ACEI/ARB
Recurrent stroke prevention	ACEI, diuretic
Pregnancy	labetolol (first line), nifedipine, methyldopa

Beta-1 Selective Beta-blockers – possibly safer in patients with COPD, asthma, diabetes, and peripheral vascular disease:

- metoprolol
- bisoprolol
- betaxolol
- acebutolol

Drug Class	Agents of Choice	Comments
Diuretics	HCTZ 12.5-50mg, chlorthalidone 12.5-25mg, indapamide 1.25-2.5mg triamterene 100mg <i>K⁺ sparing</i> – spironolactone 25-50mg, amiloride 5-10mg, triamterene 100mg furosemide 20-80mg twice daily, torsemide 10-40mg	Monitor for hypokalemia Most SE are metabolic in nature Most effective when combined w/ ACEI Stronger clinical evidence w/chlorthalidone Spironolactone - gynecomastia and hyperkalemia Loop diuretics may be needed when GFR <40mL/min
ACEI/ARB	<i>ACEI</i> : lisinopril, benazepril, fosinopril and quinapril 10-40mg, ramipril 5-10mg, trandolapril 2-8mg <i>ARB</i> : candesartan 8-32mg, valsartan 80-320mg, losartan 50-100mg, olmesartan 20-40mg, telmisartan 20-80mg	SE: Cough (ACEI only), angioedema (more with ACEI), hyperkalemia Losartan lowers uric acid levels; candesartan may prevent migraine headaches
Beta-Blockers	metoprolol succinate 50-100mg and tartrate 50-100mg twice daily, nebivolol 5-10mg, propranolol 40-120mg twice daily, carvedilol 6.25-25mg twice daily, bisoprolol 5-10mg, labetalol 100-300mg twice daily,	Not first line agents – reserve for post-MI/CHF Cause fatigue and decreased heart rate Adversely affect glucose; mask hypoglycemic awareness
Calcium channel blockers	<i>Dihydropyridines</i> : amlodipine 5-10mg, nifedipine ER 30-90mg, <i>Non-dihydropyridines</i> : diltiazem ER 180-360 mg, verapamil 80-120mg 3 times daily or ER 240-480mg	Cause edema; dihydropyridines may be safely combined w/ B-blocker Non-dihydropyridines reduce heart rate and proteinuria
Vasodilators	hydralazine 25-100mg twice daily, minoxidil 5-10mg terazosin 1-5mg, doxazosin 1-4mg given at bedtime	Hydralazine and minoxidil may cause reflex tachycardia and fluid retention – usually require diuretic + B-blocker Alpha-blockers may cause orthostatic hypotension
Centrally-acting Agents	clonidine 0.1-0.2mg twice daily, methyldopa 250-500mg twice daily guanfacine 1-3mg	Clonidine available in weekly patch formulation for resistant hypertension

INITIATING THERAPY

- Thiazide diuretic or long-acting CCB should be used as initial monotherapy in black patients.
- In most cases, monotherapy will not adequately control BP, particularly in those whose BP is more than 20/10 mmHg above goal.
- Combination therapy with drugs from different classes has a substantially greater BP-lowering effect than doubling the dose of a single agent .

COMBINATION THERAPY

- When more than one agent is needed to control the BP:
 - Combine a long-acting ACE inhibitor or ARB with a long-acting dihydropyridine CCB.
 - Combination of an ACE inhibitor or ARB with a thiazide diuretic can also be used but may be less beneficial.
 - ACE inhibitors and ARBs should not be used together.
- There is some evidence that, in patients taking more than one antihypertensive medication, shifting at least 1 drug from the morning to the evening may restore the normal nocturnal BP dip, reduce overall 24-hour mean BP, and decrease the incidence of CVD.

FOLLOW UP

- After therapy initiation
 - Reevaluate and increase therapy every 2-4 weeks until adequate BP control is achieved.
- Once BP control is achieved
 - Reevaluate every 3-6 months to ensure maintenance of control.
- For individuals > 65 years with isolated systolic HTN , caution is needed not to reduce the diastolic BP too aggressively ($<55-60$ mmHg), since low achieved diastolic pressures have been associated with an increased risk of MI and stroke

RESISTANT HTN

- BP that is above goal despite adherence to an appropriate three-drug regimen (including a diuretic) in which all drugs are dosed at 50% or more of the maximum recommended antihypertensive dose; or BP that requires at least 4 medications to achieve control
- Found in 15 % of patients diagnosed with HTN
- Exclude pseudoresistance and look for causes of secondary HTN

PSEUDORESISTANCE

It can result from some or all the following :

- Inaccurate BP measurement (eg, inappropriately small BP cuff).
- Poor adherence to BP medications.
- Poor adherence to lifestyle and dietary approaches to lower BP.
- Suboptimal antihypertensive therapy, due either to inadequate doses or exclusion of a diuretic from the antihypertensive regimen.
- White coat resistance.

TREATING HYPERTENSIVE PATIENTS WITH OTHER COMORBIDITIES

- HTN with HFrEF
- HTN with HFpEF
- HTN with stable IHD
- HTN with history of Stroke
- HTN with CKD

HTN W HFREF

- Systolic HF (EF \leq 40%)
- Goal BP <130/80
- According to GDMT (Guideline Directed Medical Therapy) for the treatment of HFREF :
 - HFBB(Heart Failure Approved BB): Bisoprolol, Carvedilol , and sustained-release metoprolol succinate, AND
 - ACE-I/ARB AND
 - Aldosterone Antagonists (if no hyperkalemia, and eGFR>30) AND
 - Loop Diuretic if fluid overload
- Nondihydropyridine CCBs are not recommended in the treatment of HTN in adults with HFREF.



HTN W HFPEF

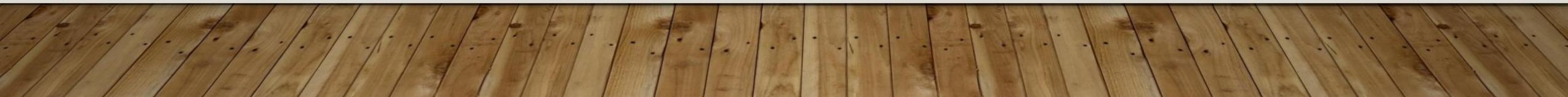
- Diastolic HF
- EF >50%
- Diuretics should be prescribed to control HTN.
- Persistence of HTN after management of volume overload:
 - ACE inhibitors or ARB AND beta blockers titrated to attain SBP < 130 mm Hg.
- Beta blockers are no longer recommended as initial monotherapy in the absence of a specific (compelling) indication for their use, such as IHD or heart failure with decreased ejection fraction

HTN W STABLE IHD

- GDMT BB: (for angina : Metoprolol, Timolol, Nadolol, Bisoprolol, Propranolol, Carvidolol)
- If still uncontrolled add ACE-I or ARB
- If still uncontrolled add dihydropyridine CCB

POST MI

- ACE-I or ARB with BB with Aldosterone antagonist



HTN WITH CKD

- An ACE inhibitor or ARB should be used for initial monotherapy in patients who have diabetic nephropathy or nondiabetic CKD complicated by proteinuria.
- This is especially important for patients with Stage III CKD or higher or stage I or II with albuminuria $> 300\text{mg/g}$ creatinine

HYPERTENSION IN CHILDREN

According to AAP 2017 report and guidelines for childhood HTN:

- 3.5% of children have HTN; another 10%–11% have elevated BP.
- This increase in prevalence is due to obesity
- High BP in childhood increases the risk for adult HTN and CVD.
- Prevalence of LVH is 30%–40% in childhood HTN
- Primary HTN tends to be systolic while secondary HTN tends to be diastolic
- Diagnosis of HTN in children requires elevated readings ≥ 95 th percentile at 3 different visits
- Diagnosis of HTN can be based on ABPM or office BP readings

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 $\geq 90^{\text{th}}$ 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 $\geq 95^{\text{th}}$ 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 $\geq 95^{\text{th}}$ percentile + 12 mmHg, or $\geq 140/90$ mmHg (whichever is lower)	$\geq 140/90$ mmHg

BP: blood pressure; HTN: hypertension.

TABLE 4 BP Levels for Boys by Age and Height Percentile

Age (y)	BP Percentile	SBP (mm Hg)							DBP (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	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	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	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

SCREENING VALUES (BASED ON 90TH PERCENTILE BP VALUES FOR CHILDREN AT 5TH HEIGHT PERCENTILE)

TABLE 6 Screening BP Values Requiring Further Evaluation

Age, y	BP, mm Hg			
	Boys		Girls	
	Systolic	DBP	Systolic	DBP
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

SCREENING FOR HTN IN CHILDREN

- Screen children without risk factors or conditions associated with HTN by measuring BP **annually**, beginning at age 3 years.
- For children with risk factors for HTN, measure BP at all health encounters.
- Risk factors for HTN in children can include:
 - Birth at <32 weeks GA, SGA, LBW, umbilical artery catheterization
 - Recurrent UTIs, renal disease or urologic malformation, F.Hx of congenital renal disease
 - Solid organ or hematopoietic cell transplant, malignancy
 - Children with obesity, taking medications known to raise BP or diabetic.

PRIMARY HTN IN CHILDREN

- Predominant cause of HTN in US children
- Characteristics include:
 - ≥ 6 years of age
 - Positive family history of primary HTN
 - Obesity/overweight
 - Do not have history or physical examination findings suggestive of a secondary cause of HTN.
- These patients with such characteristics don't require an extensive evaluation for secondary causes of HTN

SECONDARY HTN IN CHILDREN

- More likely in
 - Younger children (< 6 years)
 - Children with diastolic HTN
 - Children with nocturnal HTN
 - Children with symptoms related to underlying cause
- Retrospective case series of children with secondary HTN show that:
 - Renal parenchymal disease or renal structural abnormalities account for 34%–76%
 - Renovascular disease accounts for 12%–13%
 - Renal causes especially likely among children <6 years of age

INITIAL EVALUATION

- The initial evaluation for all children with HTN includes:
 - History and physical examination
 - Laboratory testing including: serum BUN, creatinine, and electrolytes, urinalysis, and lipid profile.
 - Echocardiography
- For obese children with HTN, additional initial studies include hemoglobin A1c and liver enzyme
- Initial imaging with renal ultrasound should be reserved for children with hypertension who are less than 6 years of age, or any child with evidence of renal disease (abnormal urinalysis or renal function). (AAP, 2017)
- For patients with a potentially reversible cause of secondary HTN, further evaluation to determine the underlying etiology.

HTN TREATMENT IN CHILDREN

- To achieve an optimal BP level:
 - SBP & DBP <90th percentile (<130/80 mm Hg in adolescents)
- At the time of diagnosis of elevated BP or HTN in child or adolescent, provide advice on the DASH diet and recommend moderate to vigorous physical activity at least 3-5 days per week (30–60 min per session).
- Prescribe antihypertensive medications if:
 - Patient has failed at least 6 months of lifestyle change
 - Symptomatic HTN
 - Stage 2 HTN without clearly modifiable risk factor (e.g. obesity)
 - Diabetes
 - LVH

HTN TREATMENT IN CHILDREN, CONT'D

- 1st line agents may include:
 - Angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB)
 - Long-acting calcium channel blocker
 - Thiazide diuretic
- In CKD or diabetes:
 - ACE inhibitor or ARB
- Refer the child for emergency care if his BP is $>95^{\text{th}}$ percentile+30 mmHg.

FOLLOW UP

- Hypertensive children treated with lifestyle change only should be seen every 3–6 months to assess success of BP reduction and to reassess need for pharmacologic treatment.
- Hypertensive children treated with antihypertensive medications should be seen every 4–6 weeks for dose adjustments until goal BP is reached, then every 3–4 months.
- Regardless of apparent control of BP with office measures, children and adolescents with CKD and a history of HTN should have BP assessed by ABPM at least **yearly** to screen for MH.

REFERENCES

- Hypertension: A Companion to Braunwald's Heart Disease, 3rd edition, 2018
- Overview of hypertension in adults, UpToDate 2021
- 2017 ACC/AHA Guideline for the Prevention, Detection, Evaluation and management of High Blood Pressure in Adults, Journal of the American College of Cardiology, Vol. 71, No.19, 2018
- AAP 2017 Report and Guideline for Childhood Hypertension