“Under Pressure”:

How to Manage Hypertension

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SBHPP 2024

agenda

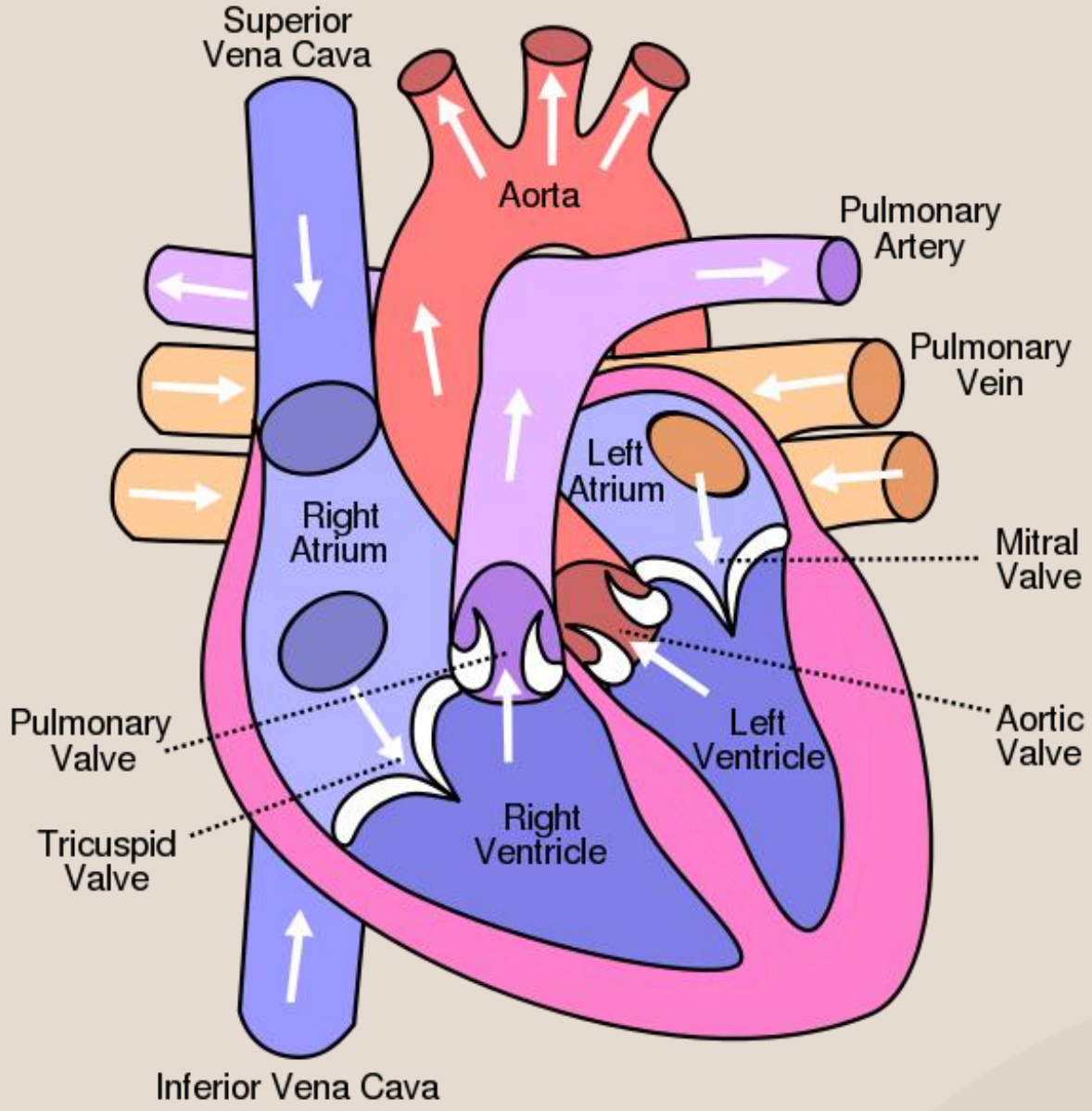
Cardiac Anatomy

Cardiac Physiology

Cardiac Pharmacology

What is “Normal”

What is “Abnormal”


Superior Vena Cava
Aorta
Pulmonary Artery
Pulmonary Vein
Left Atrium
Right Atrium
Mitral Valve
Pulmonary Valve
Aortic Valve
Left Ventricle
Tricuspid Valve
Right Ventricle
Inferior Vena Cava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"I've always been a high achiever, always striving for bigger, faster, greater...and now suddenly I'm expected to settle for *lower* blood pressure and *less* cholesterol?!"

Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

--Latest guidelines (2017- most recent)

https://giphy.com/gifs/snl-saturday-night-live-season-47-HgGNzKdlLGtzGfLjJo/fullscreen

- ACC
- AHA
- AAPA
- ABC
- ACPM
- AGS
- APhA
- ASH
- ASPC
- NMA
- PCNA

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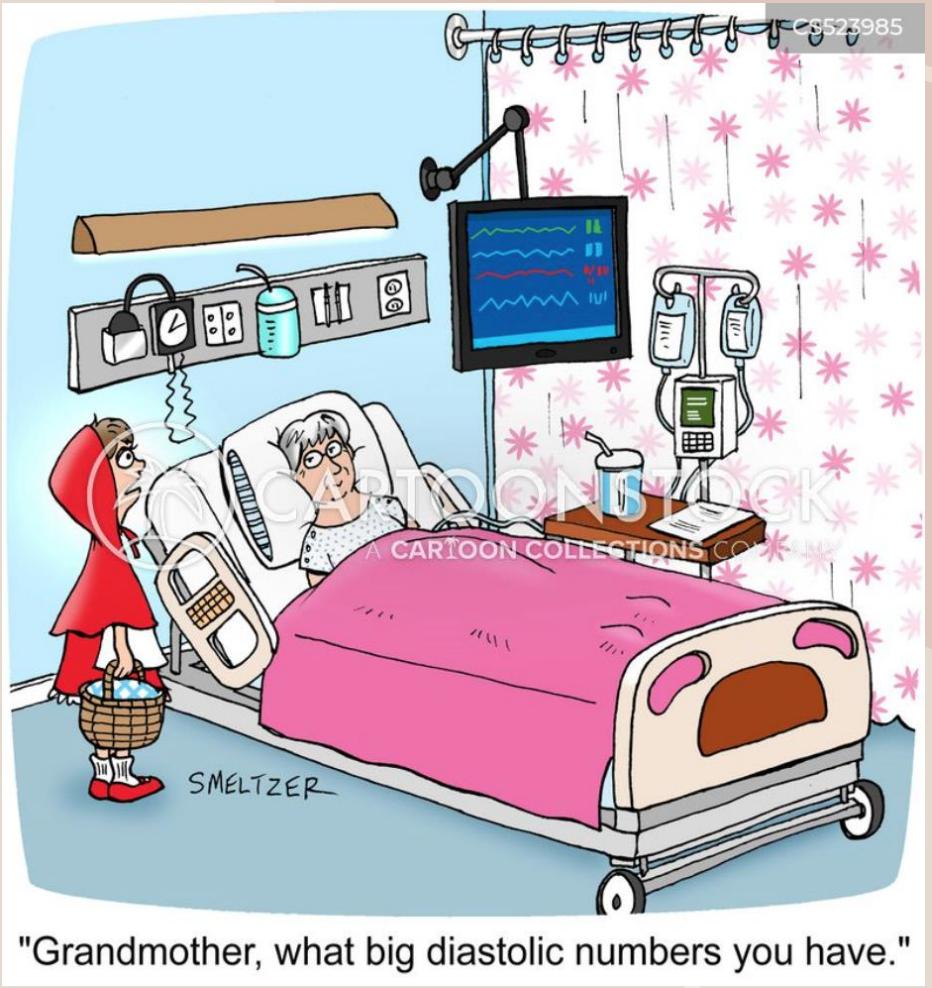
Hypertension defined

- Hypertension:
  - SBP ≥130 mm Hg or DBP ≥80 mm Hg
  - Rates: 46% of US adults
  - Ethnicity: Blacks > whites, Asians, and Hispanic Americans
  - Increases with increasing age



https://www.cartoonstock.com/directory/d/diastolic_blood_pressure.asp

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Why does hypertension matter?

- "In the United States, hypertension accounts for more Atherosclerotic Cardiovascular Disease (ASCVD) deaths than any other modifiable ASCVD risk factor"
- Meta analysis of SBP levels <115 to >180 mm Hg and DBP levels <75 to 105 mm Hg
  - **If 20 mm Hg higher SBP and 10 mm Hg higher DBP**
    - Each associated with **double the risk of death from stroke, heart disease, or other vascular disease**

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How to define “high blood pressure”

Table 6. Categories of BP in Adults*

BP Category	SBP		DBP
Normal	<120 mm Hg	and	<80 mm Hg
Elevated	120–129 mm Hg	and	<80 mm Hg
Hypertension			
Stage 1	130–139 mm Hg	or	80–89 mm Hg
Stage 2	≥140 mm Hg	or	≥90 mm Hg

*Individuals with SBP and DBP in 2 categories should be designated to the higher BP category.

BP indicates blood pressure (based on an average of ≥2 careful readings obtained on ≥2 occasions, as detailed in Section 4); DBP, diastolic blood pressure; and SBP, systolic blood pressure.

Table 7. Prevalence of Hypertension Based on 2 SBP/DBP Thresholds*†

	SBP/DBP ≥130/80 mm Hg or Self-Reported Antihypertensive Medication†		SBP/DBP ≥140/90 mm Hg or Self-Reported Antihypertensive Medication‡	
Overall, crude	46%		32%	
	Men (n=4717)	Women (n=4906)	Men (n=4717)	Women (n=4906)
Overall, age-sex adjusted	48%	43%	31%	32%
Age group, y				
20–44	30%	19%	11%	10%
45–54	50%	44%	33%	27%
55–64	70%	63%	53%	52%
65–74	77%	75%	64%	63%
75+	79%	85%	71%	78%

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Nonpharmacologic Treatment

- Behavioral strategies/lifestyle changes
- Dietary changes/modifications
- Physical activity
- Weight loss
- Sodium reduction
- Potassium supplements (if no CKD)
- Reduce alcohol intake

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When to start medications?

COR	LOE	Recommendations
I	SBP: A DBP: C-EO	1. Use of BP-lowering medications is recommended for secondary prevention of recurrent CVD events in patients with clinical CVD and an average SBP of 130 mm Hg or higher or an average DBP of 80 mm Hg or higher, and for primary prevention in adults with an estimated 10-year atherosclerotic cardiovascular disease (ASCVD) risk of 10% or higher and an average SBP 130 mm Hg or higher or an average DBP 80 mm Hg or higher.[S8.1.2-1–S8.1.2-9]

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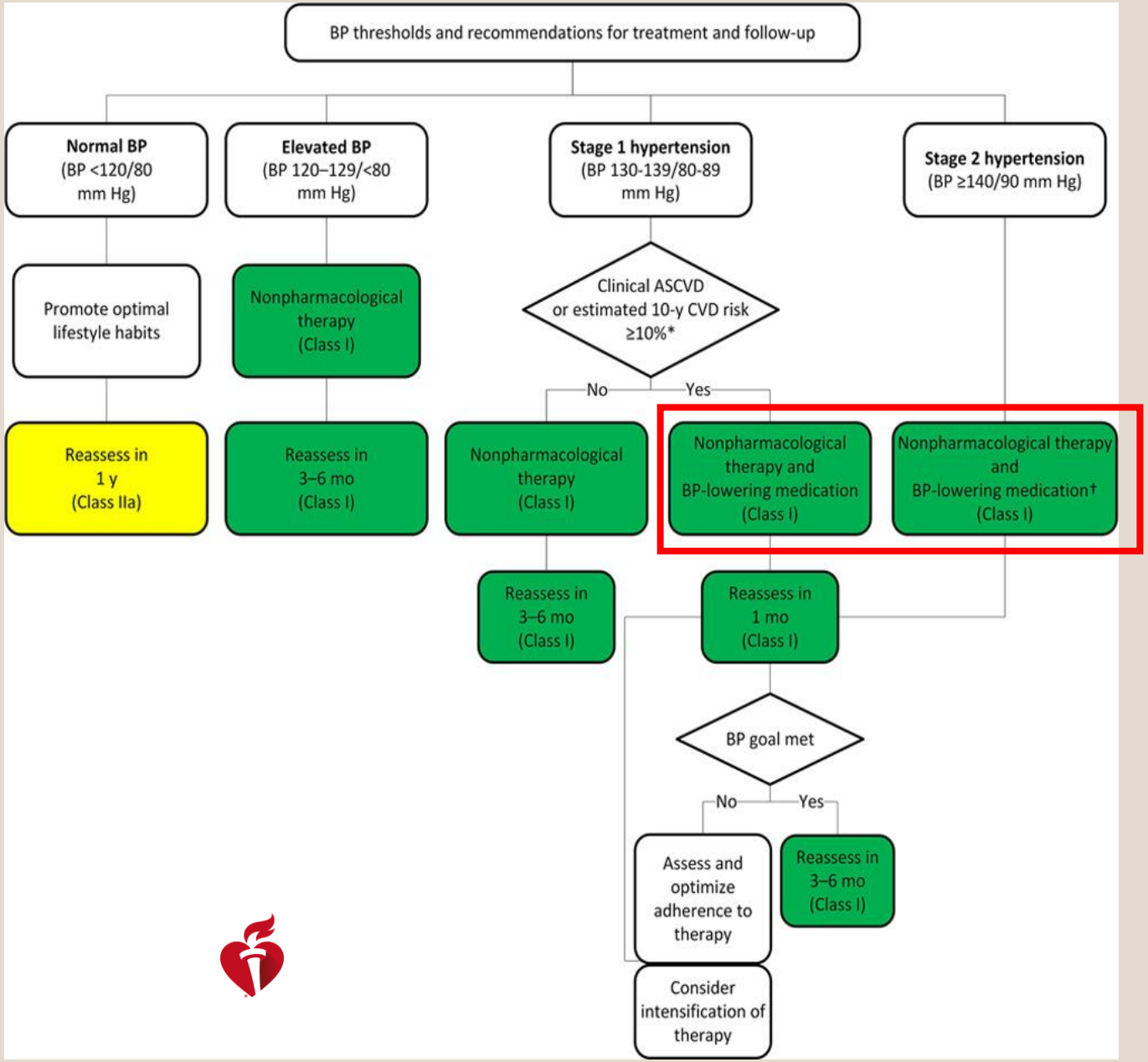
When to start medications?



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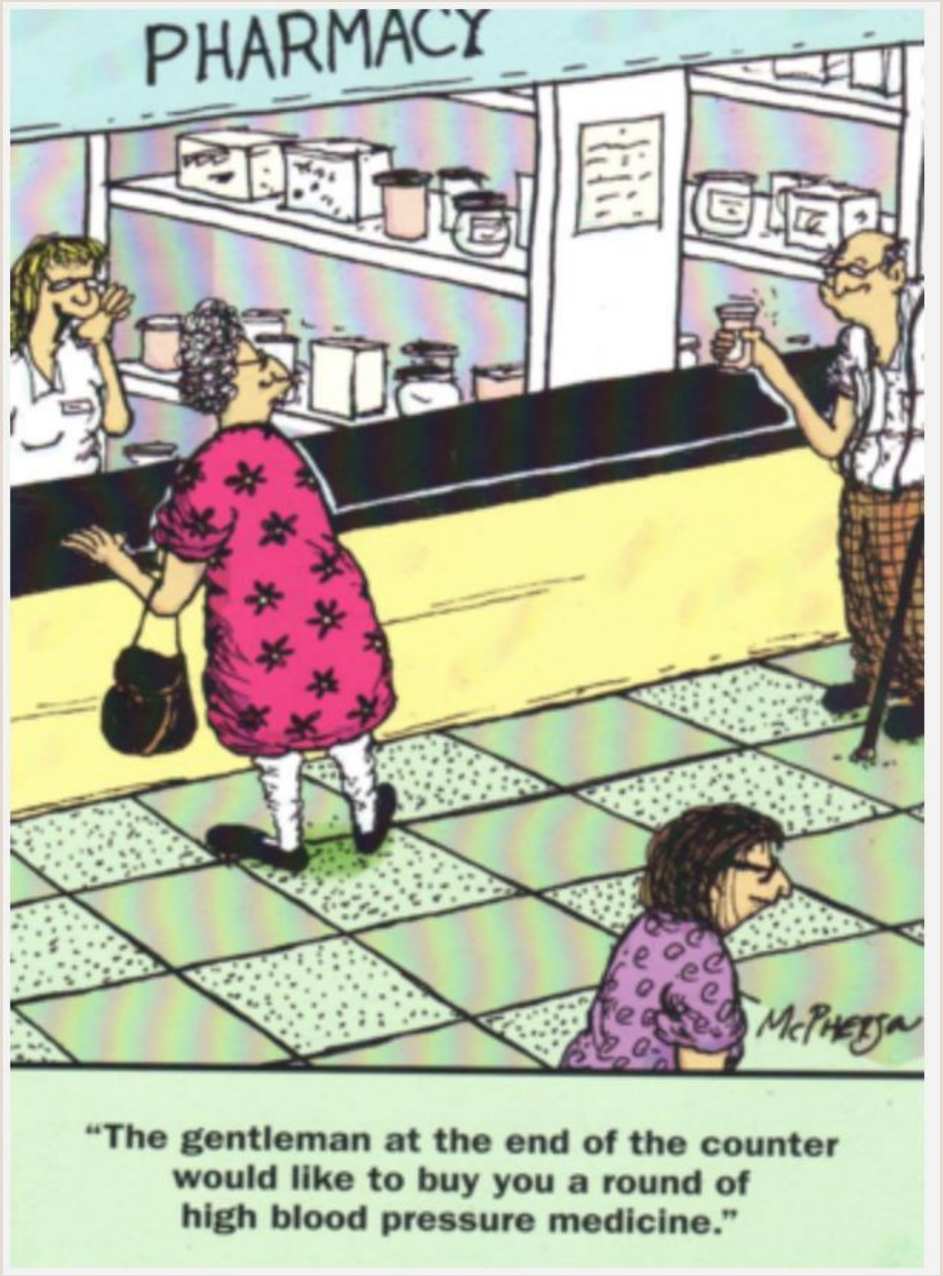

https://www.gocomics.com/blog/2264/john-mcpherson-close-to-home

Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Thiazide or thiazide-type diuretics	Chlorthalidone	12.5–25	1	Chlorthalidone is preferred on the basis of prolonged half-life and proven trial reduction of CVD.Monitor for hyponatremia and hypokalemia, uric acid and calcium levels.Use with caution in patients with history of acute gout unless patient is on uric acid–lowering therapy.
	Hydrochlorothiazide	25–50	1	
	Indapamide	1.25–2.5	1	
	Metolazone	2.5–5	1	

When to titrate:
After 2-4 weeks

Labs to check:
Metabolic panel 2-4 weeks after initiation or change

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Medication options (-pril)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
ACE inhibitors	Benazepril	10–40	1 or 2	Do not use in combination with ARBs or direct renin inhibitor.There is an increased risk of hyperkalemia, especially in patients with CKD or in those on K^+ supplements or K^+-sparing drugs.There is a risk of acute renal failure in patients with severe bilateral renal artery stenosis.Do not use if patient has history of angioedema with ACE inhibitors.Avoid in pregnancy.
	Captopril	12.5–150	2 or 3	
	Enalapril	5–40	1 or 2	
	Fosinopril	10–40	1	
	Lisinopril	10–40	1	
	Moexipril	7.5–30	1 or 2	
	Perindopril	4–16	1	
	Quinapril	10–80	1 or 2	
	Ramipril	2.5–20	1 or 2	
	Trandolapril	1–4	1	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

NOTE:

- ACEi can cause a **dry cough**
- **Avoid with AKI**
- Caution with CKD, ACEi like Lisinopril may help to slow CKD progression

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Medication options (-sartan)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
ARBs	Azilsartan	40–80	1	Do not use in combination with ACE inhibitors or direct renin inhibitor.There is an increased risk of hyperkalemia in CKD or in those on K^+ supplements or K^+-sparing drugs.There is a risk of acute renal failure in patients with severe bilateral renal artery stenosis.Do not use if patient has history of angioedema with ARBs. Patients with a history of angioedema with an ACE inhibitor can receive an ARB beginning 6 weeks after ACE inhibitor is discontinued.Avoid in pregnancy.
	Candesartan	8–32	1	
	Eprosartan	600–800	1 or 2	
	Irbesartan	150–300	1	
	Losartan	50–100	1 or 2	
	Olmesartan	20–40	1	
	Telmisartan	20–80	1	
	Valsartan	80–320	1	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

- Consider if cough with ACEi
- **Avoid with AKI**

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Medication options (-dipine)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
CCB—dihydropyridines	Amlodipine	2.5–10	1	Avoid use in patients with HF*r*EF; amlodipine or felodipine may be used if required.They are associated with dose-related pedal edema, which is more common in women than men.
	Felodipine	2.5–10	1	
	Isradipine	5–10	2	
	Nicardipine SR	60–120	2	
	Nifedipine LA	30–90	1	
	Nisoldipine	17–34	1	

When to titrate:
After 1-2 weeks

Labs to check:
None

NOTE:
Can cause peripheral edema

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Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
CCB—nondihydropyridines	Diltiazem ER	120–360	1	Avoid routine use with beta blockers because of increased risk of bradycardia and heart block.Do not use in patients with HF*r*EF.There are drug interactions with diltiazem and verapamil (*CYP3A4* major substrate and moderate inhibitor).
	Verapamil IR	120–360	3	
	Verapamil SR	120–360	1 or 2	
	Verapamil-delayed onset ER	100–300	1 (in the evening)	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

NOTE:
Common drugs metabolized by CYP3A4: Xanax, Viagra, others

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Medication options: secondary

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Diuretics—loop	Bumetanide	0.5–2	2	These are preferred diuretics in patients with symptomatic HF. They are preferred over thiazides in patients with moderate-to-severe CKD (eg, GFR <30 mL/min).
	Furosemide	20–80	2	
	Torsemide	5–10	1	
Diuretics—potassium sparing	Amiloride	5–10	1 or 2	These are monotherapy agents and minimally effective antihypertensive agents.Combination therapy of potassium-sparing diuretic with a thiazide can be considered in patients with hypokalemia on thiazide monotherapy.Avoid in patients with significant CKD (eg, GFR <45 mL/min).
	Triamterene	50–100	1 or 2	
Diuretics—aldosterone antagonists	Eplerenone	50–100	1 or 2	These are preferred agents in primary aldosteronism and resistant hypertension.Spironolactone is associated with greater risk of gynecomastia and impotence as compared with eplerenone.This is common add-on therapy in resistant hypertension.Avoid use with K^+ supplements, other K^+-sparing diuretics, or significant renal dysfunction.Eplerenone often requires twice-daily dosing for adequate BP lowering.
	Spironolactone	25–100	1	

When to titrate:
2 weeks

Labs to check:
Metabolic panel 1 week after initiation or change (watch K+!)

NOTE:
Avoid if advanced CKD
Spironolactone: gynecomastia (change to eplerenone)

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Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Beta blockers—cardioselective	Atenolol	25–100	2	Beta blockers are not recommended as first-line agents unless the patient has IHD or HF.These are preferred in patients with bronchospastic airway disease requiring a beta blocker.Bisoprolol and metoprolol succinate are preferred in patients with HFrEF.Avoid abrupt cessation.
	Betaxolol	5–20	1	
	Bisoprolol	2.5–10	1	
	Metoprolol tartrate	100–200	2	
	Metoprolol succinate	50–200	1	
Beta blockers—cardioselective and vasodilatory	Nebivolol	5–40	1	Nebivolol induces nitric oxide–induced vasodilation.Avoid abrupt cessation.
Beta blockers—noncardioselective	Nadolol	40–120	1	Avoid in patients with reactive airways disease.Avoid abrupt cessation.
	Propranolol IR	80–160	2	
	Propranolol LA	80–160	1	
Beta blockers—intrinsic sympathomimetic activity	Acebutolol	200–800	2	Generally avoid, especially in patients with IHD or HF.Avoid abrupt cessation.
	Penbutolol	10–40	1	
	Pindolol	10–60	2	
Beta blockers—combined alpha- and beta-receptor	Carvedilol	12.5–50	2	Carvedilol is preferred in patients with HFrEF.Avoid abrupt cessation.
	Carvedilol phosphate	20–80	1	
	Labetalol	200–800	2	

Medication options: secondary (-olol)

When to titrate:
After 2 weeks

Labs to check:
None

Note:
Make sure HR reasonable before initiation

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Medication options: secondary

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Direct renin inhibitor	Aliskiren	150–300	1	Do not use in combination with ACE inhibitors or ARBs.Aliskiren is very long acting.There is an increased risk of hyperkalemia in CKD or in those on K^+ supplements or K^+-sparing drugs.Aliskiren may cause acute renal failure in patients with severe bilateral renal artery stenosis.Avoid in pregnancy.
Alpha-1 blockers	Doxazosin	1–16	1	These are associated with orthostatic hypotension, especially in older adults.They may be considered as second-line agent in patients with concomitant BPH.
	Prazosin	2–20	2 or 3	
	Terazosin	1–20	1 or 2	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change (aliskiren)
No labs needed for alpha-1 blockers

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Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Central alpha$_2$-agonist and other centrally acting drugs	Clonidine oral	0.1–0.8	2	These are generally reserved as last-line because of significant CNS adverse effects, especially in older adults.Avoid abrupt discontinuation of clonidine, which may induce hypertensive crisis; clonidine must be tapered to avoid rebound hypertension.
	Clonidine patch	0.1–0.3	1 weekly	
	Methyldopa	250–1000	2	
	Guanfacine	0.5–2	1	
Direct vasodilators	Hydralazine	100–200	2 or 3	These are associated with sodium and water retention and reflex tachycardia; use with a diuretic and beta blocker.Hydralazine is associated with drug-induced lupus-like syndrome at higher doses.Minoxidil is associated with hirsutism and requires a loop diuretic. Minoxidil can induce pericardial effusion.
	Minoxidil	5–100	1-3	

When to titrate:
After 1-2 weeks

Labs to check:
None needed

NOTE:
Clonidine can cause dry mouth
Ensure HR ok for clonidine

Can use imdur or isordil with hydralazine to treat CHF if black

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Which to use first?

- First-line agents:
  - **Thiazide diuretics**
    - **(**chlorthalidone better than CCB/ACEi/ARB to prevent HF)
  - CCBs
  - ACE inhibitors/ARBs
    - (ARBs may be better tolerated than ACE inhibitors in black patients)
  - Beta blockers (**less commonly recommend first**)
    - (less effective than diuretics to prevent stroke and cardiovascular events)
- Most hypertensive adults require >1 agent for BP

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Special cases

- For black patients (w/o HF or CKD): start with a thiazide diuretic or CCB
- Stable ischemic heart disease and HTN: GDMT (beta blockers, ACE inhibitors, or ARBs) if prior MI/stable angina as first-line therapy
- Avoid Nondihydropyridine CCBs if HFrEF
- If HFpEF use diuretics first, then ACEi/ARB/BB
- If CKD consider ACEi to slow CKD progression (ARB if ACEi intolerant)
- ARB may be more helpful if Afib
- Pregnancy: transition to methyldopa, nifedipine, and/or labetalol (no ACEi/ARB/direct renin inhibitors)

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Examples:

- 56 y.o. Asian female
- BP: 129/78 mmHg
- Obese, BMI 37

- What would you recommend?

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Answer:

- Lifestyle modifications
- Weight loss
- Exercise

Examples:

- 47 y.o. white male
- BP: 137/88 mmHg
- Obese, BMI 37 despite attempts at lifestyle modifications

- What would you recommend?

Answer:

- Thiazide diuretic

- Give an example, dose, labs to check, titration…

Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Thiazide or thiazide-type diuretics	Chlorthalidone	12.5–25	1	Chlorthalidone is preferred on the basis of prolonged half-life and proven trial reduction of CVD.Monitor for hyponatremia and hypokalemia, uric acid and calcium levels.Use with caution in patients with history of acute gout unless patient is on uric acid–lowering therapy.
	Hydrochlorothiazide	25–50	1	
	Indapamide	1.25–2.5	1	
	Metolazone	2.5–5	1	

When to titrate:
After 2-4 weeks

Labs to check:
Metabolic panel 2-4 weeks after initiation or change

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Examples:

- SAME 47 y.o. white male, now seeing him 1 year later in clinic
- He reports gaining 20 more pounds due working from home with COVID and has fallen off lifestyle modifications
- BP: 151/92 mmHg
- He is taking the hydrochlorothiazide 50 mg daily that you last prescribed for him

- What would you now recommend?

Answer:

- CCBs
- ACE inhibitors/ARBs
  - (ARBs may be better tolerated than ACE inhibitors in black patients)

- Give an example, dose, labs to check, titration…

Medication options (-pril)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
ACE inhibitors	Benazepril	10–40	1 or 2	Do not use in combination with ARBs or direct renin inhibitor.There is an increased risk of hyperkalemia, especially in patients with CKD or in those on K^+ supplements or K^+-sparing drugs.There is a risk of acute renal failure in patients with severe bilateral renal artery stenosis.Do not use if patient has history of angioedema with ACE inhibitors.Avoid in pregnancy.
	Captopril	12.5–150	2 or 3	
	Enalapril	5–40	1 or 2	
	Fosinopril	10–40	1	
	Lisinopril	10–40	1	
	Moexipril	7.5–30	1 or 2	
	Perindopril	4–16	1	
	Quinapril	10–80	1 or 2	
	Ramipril	2.5–20	1 or 2	
	Trandolapril	1–4	1	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

NOTE:
- ACEi can cause a **dry cough**
- **Avoid with AKI**
- Caution with CKD, ACEi like Lisinopril may help to slow CKD progression

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Medication options (-sartan)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
ARBs	Azilsartan	40–80	1	Do not use in combination with ACE inhibitors or direct renin inhibitor.There is an increased risk of hyperkalemia in CKD or in those on K^+ supplements or K^+-sparing drugs.There is a risk of acute renal failure in patients with severe bilateral renal artery stenosis.Do not use if patient has history of angioedema with ARBs. Patients with a history of angioedema with an ACE inhibitor can receive an ARB beginning 6 weeks after ACE inhibitor is discontinued.Avoid in pregnancy.
	Candesartan	8–32	1	
	Eprosartan	600–800	1 or 2	
	Irbesartan	150–300	1	
	Losartan	50–100	1 or 2	
	Olmesartan	20–40	1	
	Telmisartan	20–80	1	
	Valsartan	80–320	1	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

- Consider if cough with ACEi
- **Avoid with AKI**

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Medication options (-dipine)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
CCB—dihydropyridines	Amlodipine	2.5–10	1	Avoid use in patients with HF*r*EF; amlodipine or felodipine may be used if required.They are associated with dose-related pedal edema, which is more common in women than men.
	Felodipine	2.5–10	1	
	Isradipine	5–10	2	
	Nicardipine SR	60–120	2	
	Nifedipine LA	30–90	1	
	Nisoldipine	17–34	1	

When to titrate:
After 1-2 weeks

Labs to check:
None

NOTE:
Can cause peripheral edema

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Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
CCB—nondihydropyridines	Diltiazem ER	120–360	1	Avoid routine use with beta blockers because of increased risk of bradycardia and heart block.Do not use in patients with HF*r*EF.There are drug interactions with diltiazem and verapamil (*CYP3A4* major substrate and moderate inhibitor).
	Verapamil IR	120–360	3	
	Verapamil SR	120–360	1 or 2	
	Verapamil-delayed onset ER	100–300	1 (in the evening)	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

NOTE:
Common drugs metabolized by CYP3A4: Xanax, Viagra, others

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Examples:

- 47 y.o. BLACK male
- BP: 151/92 mmHg

- What would you now recommend?

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Answer:

- Start with a thiazide diuretic or CCB
- (Can use imdur or isordil with hydralazine if further agents needed)
- Give an example, dose, labs to check, titration…

Medication options

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Thiazide or thiazide-type diuretics	Chlorthalidone	12.5–25	1	Chlorthalidone is preferred on the basis of prolonged half-life and proven trial reduction of CVD.Monitor for hyponatremia and hypokalemia, uric acid and calcium levels.Use with caution in patients with history of acute gout unless patient is on uric acid–lowering therapy.
	Hydrochlorothiazide	25–50	1	
	Indapamide	1.25–2.5	1	
	Metolazone	2.5–5	1	

When to titrate:
After 2-4 weeks

Labs to check:
Metabolic panel 2-4 weeks after initiation or change

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Medication options (-dipine)

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
CCB—dihydropyridines	Amlodipine	2.5–10	1	Avoid use in patients with HF*r*EF; amlodipine or felodipine may be used if required.They are associated with dose-related pedal edema, which is more common in women than men.
	Felodipine	2.5–10	1	
	Isradipine	5–10	2	
	Nicardipine SR	60–120	2	
	Nifedipine LA	30–90	1	
	Nisoldipine	17–34	1	

When to titrate:
After 1-2 weeks

Labs to check:
None

NOTE:
Can cause peripheral edema

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Medication options

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	Verapamil IR	120–360	3	
	Verapamil SR	120–360	1 or 2	
	Verapamil-delayed onset ER	100–300	1 (in the evening)	

When to titrate:
After 1-2 weeks

Labs to check:
Metabolic panel 1-2 weeks after initiation or change

NOTE:
Common drugs metabolized by CYP3A4: Xanax, Viagra, others

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Examples:

- You are seeing a 32 y.o. female who is trying to become pregnant.
- She is taking lisinopril 10 mg daily and hydrochlorothiazide 25 mg daily
- Blood pressure is well controlled at 120/71 mmHg

- What do you want to do for her?

Answer:

- Transition to methyldopa, nifedipine, or labetalol
- DO NOT USE: ACEi/ARB/direct renin inhibitors

Examples:

- Your patient report a bothersome cough on enalapril.

- What might you transition him to instead?

Answer:

- ARB

Examples:

- You started losartan for your patient.
- Baseline creatinine: 0.97
- Creatinine 1.5 weeks later: 2.06

- What should you do?

Answer:

- Stop the ARB
- Consider other agents (such as CCB or secondary agents)

Examples:

- A patient was referred to you from another provider. The patient was previously managed on amlodipine 10 mg daily. Now the patient reports holding on to 8 pounds of fluid in his abdomen. JVP is elevated. BP now 145/91 mmHg.

- What might you consider?

Answer:

- Diuretics
- Give some examples and considerations

https://www.ahajournals.org/doi/10.1161/CIR.0000000000000678 Association Task Force on Clinical Practice Guidelines | Circulation (ahajournals.org)

Medication options: secondary

Class	Drug	Usual Dose, Range (mg/d)*	Daily Frequency	Comments
Diuretics—loop	Bumetanide	0.5–2	2	These are preferred diuretics in patients with symptomatic HF. They are preferred over thiazides in patients with moderate-to-severe CKD (eg, GFR <30 mL/min).
	Furosemide	20–80	2	
	Torsemide	5–10	1	
Diuretics—potassium sparing	Amiloride	5–10	1 or 2	These are monotherapy agents and minimally effective antihypertensive agents.Combination therapy of potassium-sparing diuretic with a thiazide can be considered in patients with hypokalemia on thiazide monotherapy.Avoid in patients with significant CKD (eg, GFR <45 mL/min).
	Triamterene	50–100	1 or 2	
Diuretics—aldosterone antagonists	Eplerenone	50–100	1 or 2	These are preferred agents in primary aldosteronism and resistant hypertension.Spironolactone is associated with greater risk of gynecomastia and impotence as compared with eplerenone.This is common add-on therapy in resistant hypertension.Avoid use with K^+ supplements, other K^+-sparing diuretics, or significant renal dysfunction.Eplerenone often requires twice-daily dosing for adequate BP lowering.
	Spironolactone	25–100	1	

When to titrate:
After 2 weeks

Labs to check:
Metabolic panel 1 weeks after initiation or change (watch K+!)

NOTE:
Avoid if advanced CKD
Spironolactone: gynecomastia (change to eplerenone)

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Future Directions:

- ARNi (Entresto)
- SGLT2i (empagliflozin (Jardiance), dapagliflozin (Farxiga), others)
- GLP1a (semaglutide (Ozembic/Wegovy/Rybelsus), others)

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thank you

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