Cardiology I Exam Notes

Cardiology Terms & Introduction

• **Preload:** the 20% of blood remaining in the atria at end of diastole
  - 80% of ventricular filling occurs before atrial kick
  - increase preload by inspiration or valsalva

• **Afterload:** the volume of blood in the ventricles after atrial contraction

• **Cardiac output:** volume of blood ejected from ventricles in one minute; normally 5 L
  - increased by increasing HR, contractility, or blood volume (or decreasing resistance)

• **Stroke volume:** volume of blood ejected with each heartbeat

• **Myocardial contractility:** ability of cardiac muscle to shorten with a given load
  - **ejection fraction:** a quantification of contractility; EF = SV/EDV
  - **Starling’s law:** stroke volume increases as end diastolic volume increases due to greater stretch on walls of ventricles

• **Stenosis:** narrowing to forward flow

• **Regurgitation (insufficiency):** backward leakage while valve should be closed

• **Collaterals:** normally nonfunctioning small vessels that interconnect coronary arteries
  - function when blockage creates upstream pressure, forcing the collaterals open

- Heart sounds review
  - S3 in CHF
  - S4 in HTN

- Coronary vessel dominance: we want to identify which artery perfuses the posterior 1/3 of the interventricular septum: is it the right coronary artery or the left circumflex (or both)?
  - SA node typically supplied by the right coronary artery, but can also be left circumflex
  - AV node supplied by whichever is dominant

- **Coronary artery disease (CAD) (aka coronary heart disease CHD):** narrowing of vessels supplying the heart caused by atherosclerosis and/or hardening of the arteries

Pharmacology: Lipid Lowering Drugs

- **Statins:** act as analogues for liver cholesterol synthesis to inhibit the actions of HMG-CoA reductase → liver upregulates LDL-R to try and draw cholesterol out of circulation
  - First line medication for lower LDL!
  - Can decrease LDL by 20-60%, decrease TG by 7-30%, and increase HDL by 5-15%
    - doubling the dose results in an additional lowering of LDL by ~6%, with HDL increase of ~10-15%
  - Proven to decrease risk of major cardiovascular events and total mortality, including CAD, MI, stroke, and peripheral vascular disease
  - Administered at bedtime, when cholesterol synthesis peaks
  - Kinds:
    i.) atorvastatin: CYP3A4 metabolism
    ii.) lovastatin: CYP3A4 metabolism
    iii.) pravastatin: less interactions = good choice for someone on many meds, urinary excretion
    iv.) rosvastatin: less interactions = good choice for someone on many meds, biliary excretion
    v.) simvastatin: CYP3A4 metabolism
  - Contraindications: pregnancy or potential pregnancy, active or chronic liver disease, concomitant use of CYP3A4 inhibitors
  - Interactions: amiodarone, cyclosporine, macrolides, protease inhibitors, large amounts of grapefruit juice
  - Side effects: elevated LFTs, myalgia (no change in CK), myopathy (CK increase), rhabdomyolysis (high CK with organ damage)
Drugs to Increase Lipoprotein Lipase Activity

- Fibric acid derivatives: stimulate PPARα, a transcription factor that promotes lipid metabolism → increased oxidation of fatty acids and increased metabolism of fatty acids
  - can reduce LDL by 5-10%, reduce TG by 20-50%, and increase HDL by 10-20%
  - trials show decrease in major coronary events
  - kinds:
    i.) gemfibrozil:
    ii.) fenofibrate:
  - contraindications: severe renal disease, severe hepatic disease
  - side effects: dyspepsia, gallstones, myopathy

Bile Acid Sequestrants:

- inhibit bile salt recycling → liver breaks down more cholesterol to make new bile
- Add to the LDL-lowering effects of statins
  - reduces LDL by 15-30%, no effect on TG, mildly helps increase HDL
- Cons: requires several doses per day, concomitant drugs must be taken at a different time
- Good for persons needing only moderate LDL lowering or women considering pregnancy
- Kinds:
  i.) cholestyramine:
  - Contraindications: TG > 400 (could increase chance of pancreatitis)
  - relative: TG > 200
  - Side effects: constipation, GI upset, decreased absorption of other drugs

Drugs to Inhibit Cholesterol Absorption

A.) Nicotinic acid (niacin): blocks the breakdown of fats needed for VLDL synthesis → shift in LDL composition from small and dense to larger and more buoyant (less likely to deposit in arteries)
  - typically used in combination with other lipid-lowering drugs
  - lowers LDL by 5-25%, lowers TG by 20-50%, and increases HDL by 15-35%
  - contraindications: chronic liver disease, gout
  - relative: DM, hyperuricemia, PUD
  - side effects: flushing (prevent with aspirin before), hyperglycemia, hyperuricemia, GI distresses, hepatotoxicity

B.) Ezetimibe: inhibits cholesterol absorption at the brush border of the small intestine
  - can be used alone to increase LDL by 15-20%, TG decrease by 5-10%, minimal increase of HDL
  - similar to bile acid sequestrant, but better tolerated
  - frequently used in combination with statins
  - contraindications: active liver disease

Fish Oil:

- used to lower TG by 20-50%, with a minor increase in LDL and HDL
- side effects: increased risk of bleeding, diarrhea
- prescription brand name is Lovaza

Clinical Medicine: Lipids

Dyslipidemia

- Lipoproteins: cholesterol, triglyceride, and insoluble fat blood transporters
- Dyslipidemia: an elevation of plasma cholesterol, triglycerides, or both
  - primary dyslipidemia: genetic causes
    - most people with LDL > 190 have some genetic component such as:
      - monogeneic familial hypercholesterolemia:
      - familial defective apolipoprotein B:
      - polygenic hypercholesterolemia:
  - detection of these disorders needs to be done in young adulthood to prevent CAD
  - usually requires a statin + a bile acid sequesterant to achieve therapeutic goals
- secondary dyslipidemia: any non-genetic cause of dyslipidemia
  - diabetes
  - hypothyroidism
  - obstructive liver disease
  - chronic renal failure
  - drugs that increase LDL and decrease HDL
  - diet
  - sedentary lifestyle
  - treat these causes first if present, then re-check LDL and establish goal based on risk category
    - switch to diet low in saturated fat and cholesterol
    - ingest soluble fiber and plant stanols & sterols
    - lose weight
    - increase activity: reduces VLDL & LDL, raises HDL
    - even as secondary prevention, exercise can reduce total mortality by 20% but won’t reduce chance of having another nonfatal MI
  - dyslipidemia promotes atherosclerosis, with greatest risk on carotid and coronary vasculature

- Metabolic Syndrome: a group of risk factors that occur together and increase the risk for coronary artery disease, stroke, and type 2 diabetes
  - Characteristics: abdominal obesity, atherogenic dyslipidemia, raised blood pressure, insulin resistance, prothrombotic state (impaired fibrinolysis and endothelial dysfunction), inflammation, elevated apolipoprotein b
  - Considered to be the secondary target of overall CAD risk reduction
  - Clinically identified by presence of 3+ of these factors:
    1.) abdominal obesity (waist > 40 in for men, 35 in for women)
    2.) triglycerides > 150
    3.) low HDL (men < 40, women < 50)
    4.) BP > 130/85
    5.) fasting glucose > 110
  - Treatment: weight management, increased activity, treat HTN, therapeutic aspirin, treat elevated triglycerides or low HDL

- Diagnostic Methods for Dyslipidemia
  - Inflammatory markers and lipid levels important for risk factor identification and modification
  - Labs
    - homocysteine: blood amino acid associated with cardiac disease, stroke, and peripheral vascular blockages
      - lowered by folic acid
      - can be genetic
    - lipoprotein A (Lpa): inhibits thrombolysis and enhances LDL retention in arterial walls
      - elevation may or may not risk factor for cardiac disease
    - apolipoprotein B: LDL component
    - lipid profile: includes total cholesterol, HDL, LDL, triglycerides
      - total cholesterol and HDL can be measured even if patient was not fasting
      - if TG are > 400, you need to adjust results of LDL level to be accurate:
        corrected LDL = total cholesterol – HDL – (TG/5)
    - direct LDL (dLDL): a measure of LDL for nonfasting patients or when TG are > 400 or when chylomicrons are present

- Screening for Dyslipidemia
  - Red flag clinical presentations: corneal arcus (cholesterol deposit in cornea) in patient under 40, xanthomas (thickening of tendons due to cholesterol accumulation), xanthelasmas
  - Lab tests
    - in patients 20-35 with risk factors (DM, FH, or other cardiovascular risks), get a fasting lipid profile every 5 years
      - if test is non-fasting, total cholesterol and HDL values are still valid
    - in patients with no known risk factors, begin screening in men at age 35 and women at age 45
-if lipids are good, continue screening every 5 years
- in pediatric patients with high cardiovascular risk (obesity, HTN, FH), get a lipid profile between 2-10 years of age, and every 3-5 years thereafter
-For patients without known CAD or CAD equivalents, calculate 10-year risk of developing CHD using Framingham scoring
  -high risk is known CAD or having a CAD risk equivalent $\rightarrow$ 20% chance of developing CAD
    -when you would want to set LDL goal < 100
  -moderate risk is having 2+ CAD risk factors $\rightarrow$ 10-20% chance of developing CAD
    -when you would want to set LDL goal < 130
  -lower risk is having no or one risk factor
    -when you would want to set LDL goal < 190

☐ Treatment of Dyslipidemia
I.) ATP III guidelines
  -Total cholesterol
    -optimal is < 200
    -200-239 is borderline high
    -greater than 240 is very high
  -Triglycerides
    -less than 150 normal
    -150-199 borderline high
    -200-499 high
    -greater than 500 very high
  -LDL: the primary target for CAD risk reduction
    -otherwise healthy individuals:
      -less than 100 is optimal
      -100-129 is near optimal
      -130-159 is borderline high
      -160-189 is high
      -greater than 190 is very high
  -HDL should be > 40
III.) Determining a treatment plan for patients
  1.) get a fasting lipid profile
  2.) determine patient history of CAD (or risk equivalents) and other high risks for CAD
    -known CAD puts pt at a 20x greater risk for MI: includes patients with angina, history of cardiovascular procedures
    -CAD equivalents:
      -diabetes
        -if female diabetic, want to increase HDL to > 50
      -symptomatic carotid artery disease
      -peripheral arterial disease
      -abdominal aortic aneurysm
    -major risk factors:
      -smoking
      -hypertension
      -low HDL (< 40)
        -low HDL alone is a strong predictor for CAD
        -low HDL associated with insulin resistance and related risks: high triglycerides, obesity, inactivity
        -other causes of low HDL: smoking, high carb intake, drugs such as $\beta$ blockers, anabolic steroids, and progesterone
        -family history of premature CAD (means there is a genetic component)
        -age (men > 55, women > 65)
    -consider other major risk factors for CAD for which targeting will not help the end outcome, although they will modify clinical judgment (???)
      -obesity: distribution more important than BMI
-inactivity: better to be fat and fit than thin and sedentary!
-impaired fasting glucose
-elevated inflammatory markers
-homocysteine
-thrombotic abnormalities
-endothelial dysfunction
-elevated triglycerides alone are a risk factor for CAD
-contributing factors: obesity, inactivity, smoking, high alcohol, high carbs, disease such as DM, chronic renal failure, and nephrotic syndrome, certain drugs including β blockers and estrogens, and genetic disorders

3.) tailor the treatment plan for each patient:
   i.) if lipid panel is optimal, encourage them to continue making good choices
   ii.) for patients without CAD or CAD risk equivalent, but abnormal lipids:
      -usually, first you will set LDL goal to reach and aim for that
      -(unless TG are > 500, then you want to address that first to prevent pancreatitis)
      -(extremely low fat diet, weight management, activity, fibric acid derivative or nicotinic acid)
      -(once this is under control, then address LDL)
      -if 2+ CAD risks, want to keep LDL under 130
      -if 0-1 CAD risks, want to keep LDL under 160
      -begin with therapeutic lifestyle changes, such as low fat diet, weight management, and increased activity (this includes patients with suspected metabolic syndrome)
      -try this for 3-6 months
      -if LDL goal is not met at follow-up with just lifestyle changes, consider meds (statin, bile acid sequestrant, or nicotinic acid)
      -if 2+ CAD risks with 10-20% calculated risk, start meds with LDL > 130
      -if 2+ CAD risks with < 10% calculated risk, start meds with LDL > 160
      -if 0-1 CAD risks, definitely start meds with LDL > 190, and maybe sooner
      -if patient is pediatric, drug therapy should begin if child is at least 8 years old
      -statins are often first line therapy in peds (adjusted dosing)
      -follow-up post meds:
      -if LDL goal is not met, add higher dose statin or another med (bile acid sequestrant, nicotinic acid)
      -if LDL goal is met but triglycerides are still elevated, set another goal for all non-HDL cholesterol (should be LDL goal + 30)
      -add or intensify meds to lower LDL, or add nicotinic acid or fibrate to lower VLDL
   iii.) for CAD or CAD equivalent patients: start lifestyle changes and meds right away
      -LDL goal is < 100 or < 70 if very high risk
      -for isolated low HDL in CAD or CAD equivalent patients, add nicotinic acid or fibrate
      -for elderly patients:
      -know that cholesterol elevates progressively with age
      -studies show that treating known CAD up to age 75 results in significant reductions in cardiac morbidity and mortality
      -treating elderly patients without known CAD (primary prevention) does not have much data

Pharmacology: Antihypertensives

☐ Choosing Pharmacotherapy
-Think about the strength of evidence for use of a particular medication
-Consider comorbid conditions and compelling indications for more aggressive therapy
-Cross-check with current meds being taken
-Consider patient insurance and cost of copay
Diuretics: increase urine flow by inhibiting ion transport in the kidney
A.) Thiazides: inhibit Na and Cl reabsorption in the distal convoluted tubule → increased urine volume, decreased blood volume
- drugs of choice in the treatment of primary HTN
  - more effective than loop diuretics unless ClCr < 30 (loop diuretics act earlier in the nephron = more time for them to work with reduced nephron functioning)
- are Ca sparing = can use in osteoporotic patients
- formulations:
  i.) chlorthalidone: twice as potent as HCTZ, most evidence
  ii.) indapamide:
  iii.) hydrochlorothiazide (HCTZ):
  iv.) metolazone:
  v.) chlorothiazide:
- contraindications: anuria, CrCl < 30, careful in gout
- side effects: hypokalemia, hyperuricemia, hyponatremia, hypercalcemia, hyperglycemia
- monitor: electrolytes, BP
B.) Loop diuretics: block Na/K/Cl cotransporter in ascending loop of Henle → decreased reabsorption of Na and Cl → increased urinary excretion, decreased blood volume
- more potent Cl reabsorption than thiazides
- commonly used to reduce pulmonary edema in CHF
- kinds:
  i.) furosemide:
  ii.) bumetanide:
  iii.) torsemide:
  iv.) ethacrynic acid:
- contraindications: anuria, volume depletion
- side effects: hypokalemia, dehydration, orthostatic hypotension, photosensitivity
- monitor: electrolytes, BP, volume status
C.) Potassium-sparing diuretics: most enhance Na excretion and retain K at the distal convoluted tubule
- not very potent alone
- kinds:
  i.) spironolactone: inhibits aldosterone R at the distal convoluted tubule
    - side effects: gynecomastia or hirsutism because it binds nonspecifically to other steroid receptors, hyperkalemia
  ii.) eplerenone:
    - side effects: hyperkalemia
- monitor: BP, electrolytes, endocrine

Drugs That Interfere with the Renin-Angiotensin System
A.) Angiotensin converting enzyme (ACE) inhibitors: prevent conversion of angiotensin I to angiotensin II → Na excretion and K retention (by decreasing aldosterone production), decreased vasoconstriction
- used in treatment of HTN and CHF
- don’t affect glucose levels
- ok to use in renal pts that have no renal function left (can’t hurt them any more)
- kinds:
  i.) benazepril:
  ii.) enalapril:
  iii.) lisinopril:
- contraindications: ARF, angioedema, hyperkalemia, pregnancy, bilateral renal artery stenosis
- side effects: hyperkalemia, renal failure (so stop if serum Cr increases by 30% or more), hypotension, cough (switch to ARB)
- monitor: BP, electrolytes, renal function
B.) Angiotensin II receptor blockers (ARBs): interfere with binding of angiotensin to its receptor → effects similar to ACE inhibitors
- ok to use in renal pts that have no renal function left (can’t hurt them any more)
- kinds:
i.) irbesartan:
ii.) losartan:
iii.) olmesartan:
iv.) valsartan:

- contraindications: same as ACE inhibitor
- fewer side effects: hyperkalemia, increased SCr, increased BUN, hypotension, syncope
- monitor: BP, electrolytes, renal function

C.) Aldosterone antagonists: act on tubules to promote Na/Cl excretion and K retention
i.) eplerenone:

D.) Direct renin inhibitors (DRIs): blocks conversion of angiotensinogen to angiotensin I
- contraindications: renal failure, hyperkalemia
- monitor: K, serum Cr

Drugs That Decrease Peripheral Vascular Resistance or Cardiac Output

A.) Direct vasodilators
i.) calcium channel blockers (CCBs): inhibit entry of Ca into cells → dilation of arteries, decrease in HR → decrease in afterload
- particularly useful in elderly pts
  • dihydropyridine CCBs: work at the peripheral vasculature
    • nifedipine: HTN and angina
    • amlodipine: HTN and angina
    - side effects: edema, flushing, headache, reflex tachycardia
  • non-dihydropyridine CCBs: work at the heart vasculature and act as a negative chronotrope (decrease HR) and negative inotrope (weakens force of contraction) = useful in a-fib
    • verapamil: HTN, supraventricular tachycardias, unstable angina, chronic angina, vasospastic angina
    • diltiazem: same as verapamil but no unstable angina
    - side effects: constipation, conduction problems
- contraindications: heart failure

ii.) other direct vasodilators
- hydralazine and minoxidil directly relax arterioles
  • hydralazine + isosorbide used in CHF for ACE/ARB intolerance
- mechanism unclear

B.) Sympathetic nervous system depressants
i.) α and β blockers: can’t acutely discontinue because this could result in acute tachycardia (downregulation of the system)
  • α-1 blockers: dilate arteries and veins
  • central α-2 agonists: used specifically during substance withdrawal or pregnancy
    i.) clonidine: an α-2 agonist that reduces central sympathetic outflow, but is associated with increased incidence of falls = only use for refractory HTN
    ii.) methyldopa: drug of choice for HTN in pregnancy (ACEI/ARB not safe) but requires multiple doses per day
      → cautious use with known CAD
      → side effects: CNS, orthostasis, peripheral edema
      → monitor: HR
  • β blockers: prevent sympathetic stimulation of the heart → decrease HR, decreased contractility, decrease cardiac output, and decrease renin
    - questionable role in treatment of essential HTN unless pts have heart failure or recent MI
    - strict β-1 blockers: use for asthma or COPD pts (don’t want to block bronchial relaxation)
Clinical Medicine: Hypertension

Hypertension Background
- leading cause of death worldwide
- 75% of diabetics have HTN
- an treatable risk factor for stroke, CHF, peripheral vascular disease, aortic dissection, a-fib, kidney failure, dementia, MI
- hypertension has greatest impact on cerebral and renal vasculature!
- pulse pressures is the difference between systolic and diastolic
- diastolic pressures rise natural until age 50 and then decreases progressively, while systolic BP rises throughout life → increase in pulse pressure
- fatality of HTN is correlated to the pulse pressure
- the larger the difference, the greater the risk for fatal MI or stroke
- HTN developed before age 50 typically involves systolic and diastolic BPs
- HTN developed after age 50 is isolated systolic HTN, due to unavoidable hardening of the large arteries
- systolic BP > 140 is considered to be a greater cardiovascular risk in this age group than high diastolic BP

• Resistant hypertension: persistence of BP > 140/90 despite treatment (and patient compliance) with full doses or 3 or more different classes of meds (including a diuretic)
- could be pseudoresistant hypertension (white coat syndrome): chronic HTN is well controlled outside of the office
- inadequate medical regimen for patient: not using appropriate diuretic, renal impairment, inadequate dosing
- patient nonadherence or faulty diet: high salt, alcohol, tobacco
- exacerbating drugs: cocaine, methamphetamine, NSAIDs, other stimulants, oral contraceptives, EPO, natural licorice, cyclosporine, tacrolimus, herbal products
- consider causes of secondary hypertension

• Primary (essential) hypertension: idiopathic but with known risk factors; 95% of all cases
- risk factors affect extracellular fluid volume, heart contractility, or vascular tone:
  - can have genetic defect for impaired sodium excretion
  - stress, obesity, drug or substance abuse
  - variable renin activity
  - variable sympathetic response
  - insulin resistance, diabetes
  - inadequate dietary potassium and calcium
  - resistant vessels

• Secondary hypertension: has an identifiable, treatable cause; 5% of all cases
- a result of:
  • chronic renal disease: causes expanded plasma volume with peripheral vasoconstriction
  - most frequent cause of secondary HTN
  - and HTN can also cause CKD
  - 85% of CKD pts will develop secondary HTN
  - would see proteinuria and elevated creatinine
• **renovascular stenosis**: occurs when ill-perfused kidneys (due to atherosclerosis or fibromuscular dysplasia) release a lot of renin → vasoconstriction
  - stenosis due to fibromuscular dysplasia will have a knobbled appearance on cardiac cath
  - a frequent cause of HNT refractory to treatment
• **coarctation of the aorta**: congenital abnormality causing narrowing of the aorta → increased resistance
  - often accompanies bicuspid aortic valve or Turner’s syndrome
• **hyperaldosteronism**: usually caused by aldosterone-producing tumor or hyperplasia of the adrenals → too much Na/K reabsorption → water retention
• **Cushing’s syndrome**: pituitary adenoma that produces ACTH → lots of cortisol → HTN
• **pheochromocytoma**: adrenal tumor producing catecholamine
  - typically 35-45 years old, no risk factors for HTN, may feel hot, flushed, anxious, or have a headache
  - huge problem when undiagnosed because outpouring of catecholamines during a surgical or radiologic procedure can lead to severe hypertensive crisis and death
• **Obstructive sleep apnea**: tissues sensing intermittent hypoxia summon renin-angiotensin system to increase BP

- **Hypertensive urgency**: severe elevation of blood pressure with no evidence of progressive target organ damage or dysfunction
  - no raised intracranial pressure
  - occurs when pts have known HTN but have been noncompliant with meds or diet, or regimen was inadequate
  - clinical presentation: BPs usually > 220/110, with severe headache, SOB, evidence of stable or no target organ damage
  - need to lower BP slowly over several hours: laflol, clonidine, captopril
  - lowering too much too fast could cause dramatic drop in pressures → cerebral hypoperfusion and infarct
- **Hypertensive emergency**: acute, severe elevation of BP with evidence of rapidly progressing target organ damage
  - clinical presentation: BPs usually > 220/140, SOB, chest pain, altered mental status, weakness, dysarthria
  - target organ damage presenting as MI, acute CHF with pulmonary edema, renal failure, encephalopathy, intracranial hemorrhage, eclampsia (with pregnancy), aortic dissection
  - if seeing papilledema on funduscopic exam, think **malignant hypertension**
  - most common in young adults with prior renal disease, black males, pregnancy, or collagen vascular disease
  - treatment requires immediate and gradual reduction of BP but not to normal parameters, only to < 160/110
  - 10% decrease in 1st hour followed by 15% decrease in next 3-12 hours
  - requires use of IV meds:
    - for vasodilation: sodium nitroprusside, nicardipine, fenoldopam, nitroglycerin, enalaprilat, clevidipine, furosemide
    - adrenergic blockers: laflol, esmolol, phentolamine

- **Screening for HTN**
  - USPSTF strongly recommends screening for all adults, at a minimum of every 2 years

- **Diagnosing HTN**
  - JNC7 HTN guidelines:
    - Normal BP: <120/<80
    - Pre-HTN: 120/80 – 139/89
    - HTN stage I: 140/90 – 159/99
    - HTN stage II: >160/>100
  - HTN = repeatedly elevated pressures >140/90
    - should be based on 2+ readings that are at least 1 week apart
    - may want to treat high risk individuals at a lower threshold (130/80)
      - ex. diabetics, CKD, cardiovascular disease, cerebrovascular disease, LVHs
    - cautiously treat isolated systolic HTN in the elderly
      - indapamide +/- perindopril a good route to go
- in pregnancy can only use certain meds: methyldopa, laβlol, hydralazine, nifedipine
- Assess target organ damage: neurologic, ophthalmic, cardiovascular, renal, vascular
- labs: UA for proteinuria, blood chemistry (creatinine, glucose, K, Na), lipid profile, EKG to look for LVH
- Assess cardiovascular risk
- black patients have greater risk of complications from untreated HTN
- Detect rarer, secondary causes of HTN

Management of HTN
- Lifestyle modification
  - weight loss and DASH diet has the greatest effect
  - Meds: most single meds will only lower BP by 10-20 points, so pt will probably need multiple
    - otherwise healthy individuals
      - prehypertension → should start with lifestyle changes
      - stage I HTN → usually start with a thiazide diuretic
      - stage II HTN → 2 drug regimen with one being a thiazide
    - high cardiovascular disease risk groups require tighter control (BP goal < 130/80), and intervention with drugs begins at the prehypertensive stage: CHF, CAD, CKD, DM, post MI, post stroke
    - classes of anti-HTN meds with additive effect against comorbid diseases
      - CHF: diuretic, β blocker, ACE inhibitor, ARB, aldosterone antagonist
      - CAD: β blocker, ACE inhibitor, Ca channel blocker, diuretic
      - MI: β blocker, ACE inhibitor, aldosterone antagonist
      - diabetics: β blocker, ACE inhibitor, diuretic, ARB
      - CKD: ACE inhibitor, ARB
      - stroke: ACE inhibitor, diuretic

Pharmacology: Ischemic Heart Disease

CAD
- Pharmacologic goal is to reduce the myocardial oxygen demand
  - β blockers reduce HR and contractility
  - Ca channel blockers reduce systemic vascular resistance and decrease contractility
  - nitrates cause venous dilation → decrease preload → decrease oxygen demand
  - antithrombotics like aspirin prevent clots in the coronary arteries

Antiplatelet Drugs
A.) ADP-R antagonists:
  - kinds:
    - i.) aspirin:
    - ii.) clopidogrel:
    - iii.) ticagrelor:
      - side effects: dyspnea, brady arrhythmias
    - iv.) preasugrel:
B.) Glycoprotein IIb/IIIa-R antagonists: prevent platelet aggregation by blocking the binding of fibrinogen and vWF to the glycoprotein-R on platelet surfaces
  - kinds:
    - i.) abciximab: only if PCI planned
      - side effects: bleeding, thrombocytopenia, allergic reaction, hypotension
    - ii.) eptifibatide: renal dosing available
      - side effects: bleeding, hypotension
    - iii.) tirofiban: renal dosing available, may be less effective than abciximab during PCI

Thrombolytic Drugs: activate plasminogen → fibrinolysis
- Kinds:
  - i.) alteplase
ii.) **reteplase**;
iii.) **tenecteplase**:

- **Nitrates**: dilate blood vessels to reduce cardiac preload and reduce vessel resistance ➔ decreased end diastolic volume ➔ decreased stress on myocardial walls ➔ decreased oxygen demand by the myocardium
  - Kinds:
    i.) **isosorbide dinitrate**: oral long-acting
    ii.) **isosorbide mononitrate**: oral ong-acting
    iii.) **nitroglycerin**: PRN or chronic, spray, ointment, patch, paste, or oral
  - Drug of choice for relieving acute coronary spasm causing angina
  - Side effects: headaches, postural hypotension, flushing, dizziness, reflex tachycardia

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**Clinical Medicine: Ischemic Heart Disease**

- **Diagnostic Methods Background for Ischemia**
  - Procedures: myocardial ischemia workup
    1.) first, do a resting EKG
    2.) after that:
      - a.) normal resting EKG ➔ consider doing a stress test (exercise tolerance test): EKG on a treadmill
      - keep in mind contraindications for any exercise testing
        - absolute: acute MI in last 48 hours, refractory unstable angina, arrhythmias causing hemodynamic issues, symptomatic/severe aortic stenosis, uncontrolled/symptomatic CHF, acute PE, acute myocarditis or pericarditis, acute aortic dissection
        - relative: LCA stenosis, moderate stenotic valvular disease, severe HTN, electrolyte abnormalities, hypertrophic cardiomyopathy, tachy/brady arrhythmias, 2nd or 3rd degree AV block
      - if patient can’t exercise, consider doing a pharmacologic stress test: agent injected to simulate exercise
        - **dobutamine** will stimulate increased cardiac contractility and systemic vasoconstriction
          - contraindications: BP > 180/120, history of v-tach or a-fib, MI in last 3 days, aortic stenosis, recent β blocker
        - **adenosine** and persantine: increase flow in non-diseased coronary arteries = can better visualize blocked areas when using contrast
          - adenosine contraindications: COPD, asthma, emphysema, recent β blocker, recent theophylline, recent caffeine
          - persantine contraindications: asthma, emphysema, severe COPD, resting systolic BP < 100, LCA disease, unstable angina, acute MI, recent β blocker, recent theophylline, recent caffeine
      - hold the β blockers before the test! want to be able to achieve HR
      - other drugs that can blunt BP or HR: digoxin, β-adrenergic blocking agents, vasodilators
  - Interpretation of stress test:
    - ST changes without angina ➔ 70% chance of significant CAD
    - ST changes with angina ➔ 90% chance of significant CAD
    - bottom line: the greater the ST changes, the greater the chance of CAD
    - a systolic BP drop > 10 points ➔ BAD NEWS BEARS, indicative of severe disease that can’t be compensated for by raising BP
  - ***remember that false positives are common on stress tests***

b.) if resting EKG is abnormal ➔ do an exercise echo (real exercise or pharmacologically induced) or nuclear stress test or cardiac stress MRI
  - **stress echocardiography**: evaluates cardiac blood flow indirectly by assessing effect of exercise on myocardial wall motion
-movement interpretation depends on the reader performing the echo
-sensitivity and specificity affected by presence of baseline wall movement
abnormality, poor imaging windows, adequacy of exercise, and presence of
bundle branch blocks
-highly specific

• nuclear stress test: imaging using radioactive tracers used to look for ischemia and
infarcts
-highly sensitive

• cardiac stress MRI: radiofrequency waves and magnetic fields used to generate detailed
images of the heart

- adenosine is the only agent used for cardiac MRI
-excellent choice for valvular disease, ischemia, aortic abnormalities, congenital
abnormalities
-costly!
-contraindications: gunshot wound, shrapnel, metal prosthesis, or other source of
metal, obesity, claustrophobia

3.) if needed ➔ cardiac catheterization: gold standard for imaging, utilizes radiation and contrast
-can put in stent during same procedure
-left heart route goes in through femoral or radial artery
-allows for assessment of LV function: EF, left ventricular end diastolic pressure
-assessment of aortic & mitral valves
-assess for wall movement abnormality or LVH
-assessment of coronary anatomy
-can allow for imaging of abdominal aorta, renal arteries, iliac arteries

-right heart route goes through femoral vein into vena cava
-can assess RV pressures & pulmonary HTN
-assess for shunts or congenital abnormalities
-assess for valvular abnormalities
-assess for constrictive or restrictive pericarditis

-Procedures: STEMI or NSTEMI

1.) EKG

2.) plain-style echocardiography (obviously no exercise with it) or other imaging

3.) primary percutaneous coronary intervention (aka PCI or angioplasty): mechanically widening
obstructed arteries using a stent
-can be done during cardiac catheterization

4.) coronary artery bypass grafting (CABG): arteries or veins harvested from elsewhere in the patient are
grafted to areas of blockage to allow blood fluid to circumvent the obstructed area

-Lab monitoring for ACS drug treatment
-monitor UFH with PTT
-monitor LMWH therapy with anti-factor Xa test
-can’t monitor fondaparinux
-if using warfarin, monitor INR

-Cardiac labs:

• creatinine phospokinase (CK): found in skeletal muscle throughout the body
-show up in 1-6 hours, peaks in 12, lasts up to 1.5 days
-takes time to do the complete assay
-includes components of muscle, cardiac, and brain tissue

• CK-MM: skeletal muscle specific creatinine kinase, elevated in trauma or crush injury
- will also be elevated after running a marathon or lifting weights

• CK-MB: cardiac specific creatinine kinase, elevated in MI
-can now test directly for
-helpful to know because EKG will not always detect MI when cardiac enzymes will
show elevation

• CK-BB: brain specific creatinine kinase, elevated in stroke
-shows up in 3-12 hours, peaks at 1 day, lasts 2-3 days

• troponin T (tnT): cardiac specific damage marker
-will include all cardiac damage, including damage from defibrillation, arrhythmias, cardiac procedures, CHF, myocarditis, vasospasms, cardiomyopathies
-elevation begins within an hour of the infarct occurring (first marker to show)
drawn serially to see progression of MI
-remains elevated for 5-14 days after MI
= helpful for pts who waited to get treatment or had minimal symptoms
-problem: it is falsely elevated in renal disease due to decreased clearance

- aspartate aminotransferase (AST): nonspecific liver enzyme
- lactate dehydrogenase (LDH): found in all cell injury states = nonspecific
  - shows up in 10 hours, peaks at 1-2 days, lasts 10-14 days
- myoglobin: nonspecific marker of muscle necrosis
  - shows up in 1-4 hours, peaks at 6-7, lasts up to 1 day
  - now is typically replaced by troponin tests
- brain natriuretic peptide (BNP): secreted from ventricles stressed by CHF
  - levels can vary individually = use it as a gauge, not a specific or sensitive test
  - falsely elevated in renal failure
  - levels rise with age
- C reactive protein (CRP): a nonspecific acute phase inflammatory protein
  - elevated a few days PRIOR to MI
  - can be elevated chronically with inflammation-prone individuals (hormone therapy, tobacco)
  - levels are artificially lowered by statins, niacin, fibrates, moderate alcohol, aspirin, exercise, weight loss
  - a more specific and sensitive version of the test is hsCRP

**Coronary Artery Disease**

I.) Pathophysiology

-affects large and medium arteries
-characterized by endothelial dysfunction, vascular inflammation, lipid/cholesterol/Ca/cellular debris buildup in vessel wall
-can also cause electrical problems
-begins in childhood with lipid deposition and inflammation
  - inflammatory events: LDL oxidation, infection, toxins (nicotine), hyperglycemia, increased homocysteine
    - oxidized LDL impairs vasodilation → continual vasoconstriction
  - inflamed vessel wall attracts sticky LDL as well as macrophages
-progressions of plaques influenced by risk factors
  - can become calcified
  - risks promoting atherosclerosis: age, gender (women protected by estrogen), FH, sedentary lifestyle, tobacco, HTN, diabetes or insulin resistance (causes greater atherosclerosis), hyperlipidemia
  - smoking has greatest effect on carotid and peripheral vasculature
    - diabetics are considered to be at the risk of CAD that a normal person who has already had one MI is at
      - diabetics have accelerated atherosclerosis with many small plaques scattered throughout vs a non-diabetic who has a few, large, isolated blockages
      - diabetes has greatest effect on coronary vasculature
    - diabetics are at greater risk of CHF or death after having an MI, bypass, or stent
    - acute MI is from a plaque deposit that has suddenly burst → activation of body clotting system → ischemia
    - MI can also happen from progressive narrowing of vessels
      - slow process → formation of collaterals → progressive angina

II.) Classification of CAD to normalize between providers:

- **class I:** no limitations or symptoms with normal activity
- **class II:** slight limitations and normal activity results in symptoms
- **class III:** marked limitation and minimal activity results in symptoms
- **class IV:** symptoms present with minimal activity and at rest
Causes of Chest Pain: must determine true cardiac chest pain vs non-cardiac chest pain

• **stable angina**: chest pain with activity or stress
• **unstable angina**: chest pain at rest

A.) Pain with determined cardiac origin = must be some kind of coronary ischemia
- atherosclerosis, occlusion caused by vasospasm (cocaïne, methamphetamines, stimulants), coronary artery dissection from blunt trauma, congenital abnormalities, aortic stenosis, hypertrophic cardiomyopathy, coronary thrombus or embolus (missed warfarin dose?), acute aortic dissection

B.) Pain with non-cardiac origin
- costochondritis is reproducible on palpation
- intercostal shingles
- cervical or thoracic spine disease, including thoracic outlet syndrome
- GI: peptic ulcer disease, GERD, chronic cholecystitis
- pulm: PE, pneumonia, pneumothorax

CAD Presentations

1.) **Angina pectoris**: stable angina; deep pressure-like pain in substernal region that may radiate to neck or jaw following physical exertion or emotional stress
- transient, 2-30 minutes only
  - remits with rest or sublingual nitroglycerin
- usually as a result of chronic coronary atherosclerosis
- clinical presentation: SOB, elevated BP, S4+, arterial bruits, abnormal funduscopic exam (papilledema, AV nicking, cotton wool, corneal arcus (bluish rim around iris)), xanthelasma or xanthelomas, CHF from transient LV dysfunction, murmurs (during ischemic event only from transient papillary muscle dysfunction)
  - "typical" pain symptoms more common in middle-aged men, and may be absent in women, elderly, and diabetics
    - elderly: weakness, SOB, alt ment
    - women: anxiety
    - diabetics: SOB

- investigation:
  - EKG between angina might be normal or may show Qs from prior MI, LBBB, RBBB, fascicular blocks
  - EKG during angina may show ST depression (from the angina) or elevation (from injury incurred), or T wave inversion (from the ischemia)
- labs:
  - CK, CKMB, troponin should be negative
  - elevated cholesterol, high glucose
- CXR: may be normal or show evidence of CHF or arterial calcifications
- stress test:
  - development of typical angina + ST changes is highly indicative of CAD
    - no ST changes = 70% chance
  - BP drop during exercise means severe blockage
  - no angina? ST segment changes might still be significant for CAD

- treatment
  - work on risk factors
  - meds: daily aspirin, clopidogrel, β blocker, ACE inhibitor, nitrates PRN, statins
  - stent or bypass if necessary

2.) **Acute coronary syndrome**: includes STEMI, NSTEMI, or unstable angina
- typically from acute plaque rupture followed by thrombus
  - can also have MI from cocaine overdose (causes vasoconstriction or makes myocardium hypermetabolic), or chronic cocaine use (causes cardiac arrhythmias)
    - in this case, give a β blocker
- clinical presentation:
  - acute MI: new, sudden chest pain, jaw, neck, throat, scapular, or arm pain, dyspnea on exertion, nausea, vomiting, diaphoresis, fatigue, hypo or HTN, tachy or bradycardia, S3+ and/or S4+, signs
of CHF, systolic murmurs (may hear ventricular septal defect murmur from heart blown due to high pressure)
- will also hear a friction rub on day 2-3
- unstable angina: chest pain is now with greater frequency, severity, with less activity, or at rest
- pain is refractory to nitroglycerin

-investigation
- EKG likely to show inverted T waves (ischemia) and ST depression or elevation
- labs: cardiac enzymes will tell you if it is unstable angina vs NSTEMI
- MI will cause myocyte death \(\Rightarrow\) positive labs

-initial treatment for suspected STEMI or NSTEMI
1.) antiplatelet therapy: give aspirin and clopidogrel
   - prasugrel can be used in place of clopidogrel if PCI is planned (may have better outcome)
   - but avoid in active bleeding, planned CABG, over age 75, prior stroke or TIA
   - ticagrelor can be used in place of clopidogrel with or without PCI (may have better outcome)
   - but avoid in active bleeding or history of ICH
2.) initiate anticoagulant therapy
   - no PCI needed or expected: UF heparin or enoxaparin (LMWH) best
   - fondaparinux (factor Xa inhibitor) good for patients with increased bleeding risk
   - warfarin only used for certain indications (mechanical valve, pulmonary embolism, atrial fibrillation) due to increased bleeding risk
   - continue for duration of hospital stay
   - planned PCI: UF heparin or enoxaparin best
   - bivalirudin can also be used with heparin allergy
     - but can’t give bivalirudin if any lytics were given!
   - stop after PCI procedure
3.) when to give glycoprotein IIb/IIIa antiplatelet drugs: abciximab, eptifibatide, or tirofiban
   - STEMI: yes if PCI planned
   - then stop after PCI procedure
   - NSTEMI: yes if PCI or other diagnostic catheterization planned
4.) regain perfusion
   - best choice is PCI if available, but must be done within 3 hours of chest pain onset
   - PCI unavailable (and for STEMI only) \(\Rightarrow\) initiate fibrinolytic therapy: streptokinase, alteplase, reteplase, or tenecteplase
     - estimate risk of intracranial hemorrhage before giving
     - lytic contraindications: prior hemorrhagic CVA, ischemic CVA in last 3 months, active internal bleeding, known intracranial neoplasm, suspected aortic dissection, most recent chest pain > 12 hours ago, cerebral arteriovenous malformation
       - relative: BP > 180/110, lumbar or other noncompressible puncture, CPR > 10 min, pregnancy, menstruation, trauma in last 2-4 weeks, major surgery in last 3 weeks
5.) determine bypass vs angioplasty during PCI imaging
   - bypass or angioplasty:
     - if only 2 vessels have blockage but proximal LAD is involved
   - bypass only:
     - if LCA blockage > 50-75%
     - if 3 vessels have blockage and EF is < 50%
       - if EF is > 50%, still consider doing bypass if the angina was severe, with prior MI, or with resting EKG changes
     - if only 1-2 vessels have blockage but EF is < 50% with ischemia occurring at low exercise
   - angioplasty has a questionable outcome for 3 vessel blockage
6.) other interventions: give oxygen, monitor serial EKGs and cardiac enzymes
-half of STEMI deaths occur within 1 hour of event from ventricular fibrillation
-meds to continue at home after ACS event (STEMI/NSTEMI or unstable angina)
-clopidogrel 2-4 weeks to 1 year
-1 year if stent was placed
-daily aspirin
-statins
-ACE inhibitor (or ARB if ACEI intolerant)
-β-blocker (slowly titrate off if patient has LV failure),
-try Ca channel blocker if unsuccessful
-nitrates PRN or continuously (but no mortality benefit)
-prognosis
-complications: arrhythmias, CHF, right ventricle infarction, ventricular ruptures, mural thrombi (thrombi adhered to vessel walls), stroke, pericarditis, angina

3.) Sudden cardiac death: unexpected and nontraumatic death in stable patients who die within 1 hour after onset of symptoms
-cause: ventricular tachycardia, acute ischemia or infarction
- rarely, congenital deformities, pulmonary HTN, neoplasm, sarcoid/amyloid, vasculitides, LVH, conduction disorder

4.) Prinzmetal’s angina (variant angina or vasospastic angina): angina at rest caused by vasospasms of coronary arteries, with no correlation to stress or exertion
-sites of spasm (typically RCA) frequently adjacent to plaques
-EKG shows ST elevations
-only affects women less than 50!
-may be associated with migraines, Reynaud’s
-treatment: pt must refrain from all stimulants and certain medications that can aggravate the spasms
-give certain prescriptions to alleviate: nitrates, Ca channel blockers, β blockers
-possible complications: acute MI, v-tach, v-fib, sudden cardiac death

Pharmacology & Clinical Medicine: Heart Failure

☐ Congestive Heart Failure Background
1.) Congestive heart failure: impairment of the ventricle to fill with or eject blood
-as inadequate cardiac output occurs, all organ systems are affected by reduced nutrients and oxygen
-body tries to compensate
  1.) increase ventricular filling during diastole → increased stroke volume
  2.) norepinephrine release → increased cardiac contractility
  3.) myocardial remodeling (slow): after acute event causing dead tissue there is dilation of L ventricle and scar formation over damaged area
  -gets body through the acute event but eventually → stiff area of scar tissue with improper ventricular relaxation during diastole
  ***results in an eventual DECLINE in heart function
  → reverse cardiac remodeling with ACE inhibitors
-can have low or high cardiac output CHF
  -most CHF is of the low output variety, due to:
    -pumping against high vascular resistance
  -impaired filling of stiff ventricles
-rarely CHF can result in high cardiac output
  -but each stroke volume will be low
  -chronic activation of sympathetics and renin-angiotensin-aldosterone system leads to decreased response (and vasodilation)??
-cardiac remodeling occurs
-patients are chronically volume overloaded
-high metabolic demands can result in CHF of the high output variety!
-ex. hyperthyroidism, anemia, AV fistulas, vitamin B1 deficiency, liver disease, multiple myeloma, Paget’s disease, polycythemia vera, sickle cell, tachycardia, morbid obesity, carcinoid, acromegaly, severe psoriasis
  - treat underlying cause to treat the CHF!

II.) Common causes:
  • ischemic cardiomyopathy: when blockage in artery causes hypoxic tissue that will eventually impact the pumping of the heart
  • valvular cardiomyopathy: dysfunctional valves, including regurgitation or stenosis
  • hypertensive cardiomyopathy: stiffened walls as a result of hypertension
    - frequently results in diastolic congestive heart failure:

III.) Less common causes of CHF:
  - myocardial disease:
    • dilated cardiomyopathy:
    • hypertrophic cardiomyopathy:
    • restrictive cardiomyopathy: when scarring of the pericardium restricts heart movement
    • myocarditis: infectious, toxic, or idiopathic
  - pericardial disease:
    - typically due to viral infection
    - results in stabbing chest pain that is better with leaning forward
      • pericarditis:
      • pericardial effusion/tamponade:
      • pericardial constriction:

IV.) Classification
  - Stages of CHF:
    • stage A: at high risk but no known disease yet = treat early to prevent symptoms
      - use an ACE inhibitor
      - HTN, CAD, DM, FH of cardiomyopathy
      - work in quitting smoking, increasing activity, limiting alcohol
    • stage B: asymptomatic disease
      - add a β-blocker to the treatment regimen
      - previous MI, LV systolic dysfunction, asymptomatic valvular disease
    • stage C: prior or current symptoms = symptomatic heart failure
      - add a diuretic or digoxin or device
      - reduce salt intake
      - known structural heart disease, SOB, fatigue, reduced exercise tolerance
    • stage D: advanced symptoms or refractory to treatment = end stage with marked symptoms at rest
      - stage where people get placed on heart transplant list
      - add positive inotrope or device to regimen
  - Functional classification of CHF (similar to CAD):
    • class I: no symptoms
    • class II: symptoms with moderate exertion
    • class III: symptoms with minimal activity or ADLs
    • class IV: symptoms at rest

V.) Risk factors for development of CHF: age, HTN, tobacco, DM, obesity
  - substance abuse is a risk due to constant stimulation of heart from amphetamines
  - alcoholism because associated cirrhosis may cause R sided heart failure
  - common CHF precipitators: CAD, MI, valvular disease, congenital heart disease, HTN (diastolic dysfunction), viral infection, pregnancy, idiopathic

VI.) CHF symptoms: dyspnea on exertion or at rest, paroxysmal nocturnal dyspnea, orthopnea, lower extremity, abdominal, or sacral edema (3rd spacing of extra fluid around heart), palpitations, weakness, anorexia
  - comorbid symptoms: chest pain, palpitations, fatigue, syncope
  - presenting symptoms are often only with exertion
    - exercise results in inadequate cardiac output is not perfusing tissues, so resps are increased to compensate
    - exercise increases heart rate, so ventricles have less time to fill
CHF Diagnostic Methods

1.) Echocardiography: ultrasound used to provide information about structure, anatomy, and physiology of the heart
   - no ionizing radiation generated
   - inexpensive
   - quality of the image depends on the operator’s skill, patient’s body type, presence of barrel chesting and other chest wall anatomy
   - diagnostic utility:
     - assessing cardiac structure size and function
       - LVH
       - LV dysfunction: ischemia
       - valves: morphology and mobility
       - pericardium
       - wall motion abnormalities: regional vs global
       - contractilities
       - congenital abnormalities
     - estimate ejection fraction
     - very important post-MI
     - assessing cardiac masses
     - measuring RV and pulmonary pressures
       - collapse of vena cava is normal and indicates normal central venous pressure
         - won’t collapse if pressures are high
     - assessing murmurs: diastolic and cardiac
     - evaluating syncope
     - pre-op screening for clots before ablation of irritable foci causing arrhythmias
     - assessing cardiac sources of emboli: looking for patent foramen ovale or atrial septal defect
       - biggest risk in having a communication between sides of the heart is that you lose the filtering property of having all blood flow through the lungs, so that emboli are able to move from the right side of the heart to the left
       - can use saline contrast to do a bubble study: + if bubbles seen in both sides of the heart
     - assessing pericardial effusion, pulmonary embolism, pulmonary hypertension
       • transthoracic echocardiography: standard echo, done over chest wall
       • transesophageal echocardiography: more helpful in viewing posterior structures of the heart but more invasive
         - quality not compromised by obesity or pulmonary disease
         - helpful in assessing for suspected endocarditis and subsequent valvular damage
         - improved visualization of vegetations, thrombi, masses, or left atrial appendage clot (most likely source of CVA/TIA)
   • transthoracic echocardiography: standard echo, done over chest wall
   • transesophageal echocardiography: more helpful in viewing posterior structures of the heart but more invasive
     - quality not compromised by obesity or pulmonary disease
     - helpful in assessing for suspected endocarditis and subsequent valvular damage
     - improved visualization of vegetations, thrombi, masses, or left atrial appendage clot (most likely source of CVA/TIA)

2.) EKG
   - many CHF patients will have LVH
   - end stage CHF results in low voltage due to electricity going through greater muscle mass?
     - evidence of ischemia or prior infarction (Q waves)

3.) Cardiac biomarkers if suspecting ischemic etiology
   - CK/MB
   - Troponin

4.) Cardiac cath in acute CHF with unstable angina or MI
   - do left ventriculogram to evaluate LV function, calculate EF, assess wall motion, and to look for mitral regurgitation
   - do an arch shot to assess for aortic regurgitation or aortic defects
   - do coronary angiography to assess for blockages

5.) Chest X-ray with PA and lateral views
   - look at size and shape of cardiac silhouette for cardiomegaly
     • Kerley B lines: sharp, linear densities from interlobular interstitial edema
       - pathognomonic for CHF!
   - look for pleural effusions
     - commonly caused by left sided CHF
       - effusions will be transudative, small-med sized, and free-flowing
6.) BNP levels

 baskets

 Developing a CHF Treatment Plan

 I.) History and physical exam for presenting symptoms → assess risk category

 - Vitals: O2, weight loss, BP, HR
 - Inspection: pallor, cyanosis, cool or moist skin, use of accessory muscles
 - Lungs
  - if L sided failure → crackles, rales, possible wheezes, dullness at base of lungs, frothy or pink sputum
  - if R sided failure → mostly clear lungs with dullness at the bases

 - CV/PV
  - diminished or bounding pulses
  - JVP reflects right atrial pressure elevations
    - hepatojugular reflux (press on liver to watch excess fluid increase JVP)
  - if L sided failure → S3 or S4, mitral regurgitation
  - if R sided failure → right sided S3 or S4, tricuspid regurgitation,
    - S2 sound (made of A2 and P2) is normally dominated by closure of the aortic valve (A2), but because pressures are high on the R side you will also hear a loud pulmonic valve closure (P2)

 - Abdomen
  - hepatomegaly
  - pulsatile, tender liver
  - ascites

 - Extremities
  - edema

 II.) Investigation

 - EKG & labs to assess etiology
 - Echo to assess EF
 - Cardiac cath to rule out ischemia and assess valves and pressures

 III.) Pharmacologic treatment

 - Start appropriate drug therapy for acute vs chronic disease (red = proven mortality benefit)
  - treatment goal is to decrease cardiac workload, control excess fluid, and increase contractility
  - reduce cardiac workload
    - ACE inhibitors or ARBs (-pril or -sartan): vasodilate → reduced peripheral resistance & reduced BP → reduced afterload and preload
    - won’t change HR or cardiac output
    - will aid in diuresis
    - hydralazine + isosorbide dinitrate: found to be most beneficial to black men as an add-on therapy to those already on β-blockers and ACE inhibitors that are still symptomatic
      - decreased mortality, increased EF, improved exercise tolerance
      - requires frequent dosing
      - side effects: GI, headache
    - β blockers reduce sympathetic stimulation
      - warning: can reduce cardiac output, cause bradycardia
    - dihydropyridine Ca channel blockers
    - for hyponatremic patients, you can use a vasopressin antagonist (tolvaptan), because it does not interfere with electrolyte balance, but it costs lots of $$$
    - control excess fluid
      - diuretics (thiazide, loop, or K sparing): should not be used alone
        - if renal function is impaired, use a loop diuretic
        - if one dose isn’t working, up it or add a second, or try IV infusion
      - idea of sequential nephron block: start with a loop diuretic then work sequentially down the nephron to target more distal parts
-aldosterone antagonists (spironolactone, eplerenone)
  -increase contractility
  -digitalis: improves contractility and cardiac output by inhibiting Na/K ATPase and enhancing release of Ca from SR
    -reduces plasma norepinephrine, renin, and aldosterone
    -low therapeutic index due to toxicity—only add if pt is persistently symptomatic on other drugs
    -lots of drug interactions
    -won’t distribute into fat tissue = don’t increase dose for obese pts
    -inotropes are last-resort or short-term only (life-limiting)
  -for end stage CHF waiting for transplant
  -for exacerbation, nonperfusion, or hypotension

- statins?

***Pharmacist says: avoid in all CHF patients: antiarrhythmic drugs, non-dihydropyridine Ca channel blockers, NSAIDs
  -but Sherrie says:
    -can consider antiarrhythmics (mismatch between size of R/L heart can lead to asynchronous beating)
    -anticoagulative therapy (controversial)
      -low EF → consider warfarin
    -ATP III recommends giving aspirin to reduce prothrombic state

IV.) Non-pharmacologic treatment:
  -behavioral modification
    -avoidance of salt, alcohol, other CHF exacerbators
    -exercise to make body more efficient at a given workload, to lose weight, and to prepare for transplant
  -devices
    • automatic implantable cardioverter defibrillators (AICD):
      -for those with EF < 35%
      -proven mortality benefit
    • intra-aortic balloon pump (IABP):
      -temporary measure for acute CHF in hospital
    • left ventricular assist device (LVAD): internal or external device to decrease residual volume in L ventricle and increase cardiac output
      -a bridge therapy while waiting for heart transplant
    • ultrafiltration/hemofiltration: basically dialysis to remove fluid overload
      -transplant
      -work on reduction of risk factors

V.) Prognosis
  -diet and prescription noncompliance are a major cause of hospital readmission for CHF

☐ Specific CHF Presentations and Treatments

A.) Systolic heart failure: problem with contraction, heart does not squeeze well, and cardiac output is insufficient
  -EF < 55%
  -causes:
    -most commonly ischemic heart disease and/or MI
    -long-standing HTN causes stiffening of heart wall (a diastolic problem) but will eventually wear out the pump of the heart = becomes a systolic problem
    -valvular heart disease: because greatest pressures are on left side of heart, valvular disease on left side is more symptomatic than on right side
    -idiopathic (viral infection?)
    -myocarditis
    -toxins: alcohol, cocaine, hyperthyroidism, lead
    -overwhelming illness or sepsis
    -DM
investigation: Echo for LV & reduced EF & dilation, EKG for LVH signs, CXR for cardiomegaly and/or pulmonary edema, BNP levels

B.) DIASTOLIC HEART FAILURE: heart does not relax enough → elevated filling pressures → high pressure gradient which causes water portion of blood to diffuse across heart and into tissues → edema

- EF > 55%
- preserved pumping ability, but heart will eventually wear out and EF will decline
- most common in older females with HTN
- causes: HTN → LV ventricular hypertrophy, acute ischemia, restrictive cardiomyopathy (amyloid, ESRD on dialysis, sarcoid), DM
- diastolic dysfunction naturally increases with age

investigation: Echo for LVH, EKG for LVH signs, CXR for pulmonary edema, BNP levels

Systolic/diastolic heart failure can coexist!

- ex. ischemic heart disease
  - MI causes dead tissue with loss of contracting myocardium = systolic component
  - scarring from MI cause reduced compliance of ventricle = diastolic component

C.) RIGHT-SIDED CHF

- causes:
  - most common cause is left sided heart failure: L side of heart is damaged so everything backs up into the lungs and right side of the heart
  - congenital heart lesion such as atrial septal defect
  - tricuspid or pulmonic valve disease
  - pulmonary disease such as COPD, interstitial lung disease, pulmonary emboli
  - pulmonary HTN means pressures feeding lungs are high → transfer of the pressure to the heart
  - always due to an underlying problem

D.) Acute (flash) pulmonary edema: rapid fluid accumulation in the air spaces and parenchyma of the lungs

- causes: MI, acute valvular lesion, HTN, end stage valvular disease, severe systemic illness, pulmonary embolism
- presentation: tachypnea, tachycardia, HTN (or hypo if grave), hypoxia, crackles
- treatment: IV diuretics, nitrates, inotropes, pressors, ACE/ARB or hydralazine + nitrate, morphine, anti-arrhythmics, oxygen

- DON’T give β blockers in acute phase

E.) Acute heart failure (overt)

- causes: massive MI, tachyarrhythmias, infective endocarditis with valve rupture
- presentation: severe SOB, rales, hypoxia, cyanosis, pallor, chest pain, tachycardia or bradycardia, hyper or hypotensive (BAD if hypo), cool skin, diaphoresis, tachypnea, respiratory distress, poor mental status

F.) Decompensated heart failure: decompensation of a chronic or acute heart failure; patient is clinically deteriorating and requires early and aggressive therapy

- symptoms: new or worsening of existing symptoms, dyspnea, fatigue, edema, new murmurs
  → findings consistent with worsening LV function
  - patients are "cold and wet" = cold due to hypoperfusion, wet due to pulmonary congestion and volume overload

- investigation: EKG, Echo, CXR
  - loop diuretics
  - oxygen
  - morphine to depress respirations
  - nitroglycerin or nitroprusside (if HTN) to vasodilate and reduce preload and afterload without reducing contractility
  - inotropes
    → pos inotrope to stimulate forceful heart contractions (dobutamine or milrinone)
    - dobutamine for patients in shock with low BP
    - synthetic BNP (brain natriuretic peptide) for vasodilation to decrease preload
    - huge $$$ for similar results to nitroglycerine or furosemide
  - ACE or ARB
    → DON’T give β-blocker!
  - mechanical interventions if necessary

→ figure out and treat underlying cause! (ex. thyroid, anemia)
Pharmacology & Clinical Medicine: Arrhythmias

Electrical Problems of the Heart
-Symptoms: palpitations, racing heart, dizziness, syncope
-Comorbid precipitators: CAD, MI, congenital malformations, CHF

Antiarrhythmic Drugs
-Na channel blockers: block Na entry into cell during depolarization → prolonged refractory period, and suppress automaticity of the Purkinje and His fibers
  -class IA drugs useful for treatment of atrial and ventricular arrhythmias
  -class IB drugs are used for ventricular arrhythmias
-B blockers slow conduction through SA and AV nodes and increase refractory period
  -good for treating tachyarrhythmias from excess sympathetic activity
-K channel blockers prolong repolarization
  -good for treating intractable ventricular arrhythmias
-Ca channel blockers slow conduction through AV node and increase AV refractory period
  -stop arrhythmias requiring AV conduction
-Others: adenosine, digoxin

Clinical Medicine: Cardiovascular Disease Prevention

-Primary prevention: treat risk factors to prevent development of disease
  -7 biggest risk factors
    -can’t prevent age, family history, or gender
    -can prevent modifiable risks: hyperlipidemia, hypertension, diabetes, smoking
      -often coexist with other big risk factors
    -Framingham risk is used to help decided whether or not to treat primary hyperlipidemia
      -ATP III recommends focus on lowering LDL
    -other modifiable risk factors: obesity, inactivity, CKD, metabolic syndrome, high alcohol
-Secondary prevention: treat established disease to prevent recurrence or debilitation
  -known cardiovascular disease = treat cholesterol regardless of numbers
Valvular Heart Disease, Infective Endocarditis, and Rheumatic Fever

**Background**
- Mitral valve is the only one with 2 leaflets!
- Today most valvular disease is due to degenerative calcific changes that occur naturally with aging
  - probably same mechanism as atherosclerosis
  - can lead to stenosis, regurgitation, or both
- Cardiac cath vs echo?
  - echo
    - estimates RV and pulmonary pressures
    - estimate ejection fraction
    - look at wall and valve morphology
  - cardiac cath
    - left heart route → directly measure LV and diastolic pressures
    - right heart route → directly measure RV and pulmonary pressures
    - do cardiac cath instead of echo when you want to assess CAD
- Rheumatic fever and valvular disease
  - order of valves affected by rheumatic fever: mitral, aortic, tricuspid, pulmonic
  - disease is a result of immune response to the infection vs infection itself
  - can result in regurgitation and/or stenosis
  - diagnose with Jones criteria: must have 2 major criteria or 1 major + 2 minor
    - major: carditis, polyarthritis, chorea, erythema marginatum, subq nodules
    - minor: arthralgia, fever, elevate acute phase proteins, prolonged PR interval, previous history of Group A strep or rheumatic fever
  - treatment: bedrest if there is significant cardiac disease, salicylates and steroids, heart failure management, penicillin
- **Infective endocarditis**: bacterial infection of the endocardium and/or a valve
  - can be spurred by transient bacteremias caused by IVs or operations
  - agent is usually viridans strep or staph
- organism determines acute vs subacute presentation
- at risk: those with mitral valve prolapse, bicuspid aortic valve, IVDU, prosthetic valve recipients
- presentation: fever (days to weeks), headache, myalgias, cough, arthralgias, weight loss, cardiac issues, petechiae of the palate or conjunctiva, embolic phenomena, new murmur
- subungual “splinter” hemorrhages
- painful purple lesions on the extremities (Osler nodes)
- painless erythematous lesions on the palms & soles (Janeway lesions)
- exudative lesions of the retina (Roth spots)

- investigation:
  - blood cultures, CBC $\rightarrow$ anemia, leukocytosis, elevated sed rate, UA $\rightarrow$ hematuria, proteinuria, + rheumatoid factor antibody
  - TEE (better than regular echo) $\rightarrow$ oscillating vegetations, abscesses, valve perforation or dehiscence, new regurgitation
  - Duke diagnostic criteria (2 major, 1 major + 3 minor, or 5 minor)
    - major: + blood culture, evidence of endocardial involvement
    - minor: predisposition, fever, vascular/immune phenomena, microbial involvement, echo findings?

- treatment: IV antibiotics 4-6 weeks, may need surgical valve replacement
- anticoagulation contraindicated

- prophylaxis before procedures? new guidelines say it isn’t necessary unless your patient is highest risk group (prosthetic valve, previous endocarditis, cardiac transplant with valvular disease, congenital malformations)
  $\rightarrow$ not recommended for those with prior CABG, pacemaker, ICD, mitral prolapse or regurg, atrial-septal defect, prior rheumatic fever

**Stenosis:** narrowing or obstruction to forward flow $\rightarrow$ generation of high pressure that heart must pump against
- slow progression, chronic disease
- symptoms will precede LV dysfunction
- usually intervene just for symptoms
- compensatory mechanism for increased pressure is hypertrophy: enlargement of heart wall
  - a result of concentric hypertrophy: new sarcomeres added in parallel to existing sarcomeres $\rightarrow$ wall increases in thickness
- normal LV wall thickness is $<$ 12 cm

A.) Aortic valve stenosis: obstruction $\rightarrow$ increased pressure in LV $\rightarrow$ LVH $\rightarrow$ eventual heart failure $\rightarrow$ systolic dysfunction $\rightarrow$ progression of heart failure & irreversible LV injury
- from calcification:
  - associated with 50% increase in risk of cardiovascular death and MI
  - a result of inflammation, lipid accumulation, upreg of ACE, infiltration of tissue with macrophages and T-cells
  - development has same risk factors as for CAD: HTN, hyperlipidemia, DM, smoking, metabolic syndrome
  - **senile aortic stenosis:** age-related calcific build-up on a normal tricuspid valve
    - occurs by age 60-80
  - **bicuspid aortic stenosis:** congenital abnormality that accelerates calcific build-up = stenosis
    - occurs 10 years sooner than normal age-related stenosis
    - treatment: statins
  - rheumatic fever-related aortic stenosis: causes adhesion and fusion of cusps
    - can also cause aortic regurgitation and mitral valve disease
- classification:
  - normal valve is 3-4 cm²
  - mild stenosis is $<$ 1.5 cm² with pressure $<$ 25 mm Hg
  - moderate stenosis is 1-1.5 cm² with pressure 25-40 mm Hg
  - severe stenosis is $<$ 1 cm² with pressure $>$ 40 mm Hg
- presentation:
  - if early, may be asymptomatic with murmur
    - systolic ejection: harsh, heard at aortic with potential radiation to neck
S4 from the HTN
late: DOE, SOB, angina (end-stage), syncope, CHF, paroxysmal nocturnal dyspnea, orthopnea, presyncope
exam: pulsus parvus et tardus (pulse is slow in relation to contraction, and weak), hyperdynamic displaced apical impulse
investigation: EKG for LVH, CXR for cardiomegaly, echo for valvular morphology/gradient/LV function (or cardiac cath to assess for all this plus concomitant CAD)
treatment:
- no proven benefit with drugs other than statins
- valve replacement if severe
- aortic balloon valvotomy as bridge to surgery or palliative

B.) Mitral valve stenosis: elevated LA pressure → LA hypertrophy → transmission of high pressures to pulmonary vasculature → pulmonary edema
background:
- most commonly due to rheumatic heart disease (occurs 10-20 years after fever)
  - rarely due to congenital malformation or connective tissue disease
- mostly in women
- cardiac output is reduced
- can progress to right-sided heart failure
- hypertrophy of tissue makes it unhappy and prone to electrical problems like afib
- worsens with pregnancy because there is more demand for cardiac output → increased HR
- valve size is usually < 1.5 cm²
presentation: fatigue, dyspnea, orthopnea, hematoptysis, peripheral edema, palpitations, afib (or associated embolic events)
-S1 will be loud and palpable
-opening snap of mitral stenosis after S2
-low pitched diastolic rumble at apex (best heard in LLD or accentuate with exercise)
-accentuated P2
-RV heave if it has progressed to pulmonary HTN
investigation
-use echo to classify stage
- normal if valve is 4-6 cm² with pressure gradient of 0 mm Hg
- mild if valve is 2-4 cm² with pressure < 8 mm Hg
- moderate if valve is 1-2 cm² with pressure of 8-12 mm Hg
- severe if valve is < 1 cm² with pressure > 12 mm Hg
treatment
-if asymptomatic, may only need prophylaxis for endocarditis
-initially try:
  - HTN management: diuretics & salt restriction to reduce blood volume, nitrates
  - afib management: anticoagulation for high embolic risk
  - beta-blockers: control HR to prevent pulmonary edema (greater HR = greater disparity between what is pumped out and what the lungs are returning)
-if patient remains symptomatic after meds or has episodes of pulmonary edema, decline in exercise capacity, or evidence of pulmonary HTN:
  - mitral valve replacement
  - balloon valvuloplasty

C.) Tricuspid stenosis: causes diastolic pressure gradient between RA and RV
background:
- uncommon in adults
- affects more females
- most frequently a result of rheumatic disease
- rarely an isolated disease = other mitral/aortic defects usually coexist
presentation: symptoms related to elevated RA pressures such as edema, hepatosplenomegaly, ascites, fatigue, weakness
-diastolic murmur is soft, high-pitched, and brief at left sternal border
- increases with inspiration
- JVD with giant venous A waves (whatever that means)
- palpate liver to accentuate
- treatment: if symptomatic with mean valve gradient is > 5 mm Hg \(\rightarrow\) balloon valvuloplasty or valve replacement

D.) Pulmonic valve stenosis:
- background:
  - most commonly congenital, presenting in adulthood
  - can also be acquired as a result of rheumatic fever or a complication of arrhythmia ablation procedures
- presentation: DOE, fatigue, presyncope, cyanosis
  - JVP with a-waves
  - split S2 with soft P2
  - ejection click followed by crescendo-decrescendo ("diamond") systolic murmur at left sternal border
  - common to hear S4 as well
- investigation: echo \(\rightarrow\) RV, pulmonic valve pulls up a bit ("doming") during systole due to the narrowed orifice, transpulmonic gradient

- **Regurgitation (Insufficiency):** backward leakage while valve should be closed \(\rightarrow\) increased volume in chamber springing the leak
  - mitral or tricuspid
  - can be acute or chronic
  - LV dysfunction can precede symptoms
  - need to monitor LV function
  - intervention is both for symptom management and preservation of cardiac function
  - compensatory mechanism for increased volume is dilation: enlargement of heart chambers
    - a result of eccentric hypertrophy: new sarcomeres are added in series to existing sarcomeres \(\rightarrow\)
    - sarcomeres lengthen rather than thicken but ventricles dilate to the same extent = no change in proportion

A.) Aortic valve regurgitation: causes increased end-diastolic vol in LV \(\rightarrow\) dilation of LV to accommodate \(\rightarrow\) increased end-diastolic pressure in LV \(\rightarrow\) backup into pulmonary circulation
  - from aortic cusp or valve disease
    - congenital: bicuspid or unicuspid
    - infectious: rheumatic fever, infective endocarditis
    - inflammatory: SLE, RA
    - anorexic drugs
  - from disease of aortic root: unhealthy tissue of cusp, annulus, or valve
    - ex. Marfan syndrome, syphilis, ankylosing spondylitis, cystic medial necrosis, aortic dissection, trauma
  - presentation
    - if acute \(\rightarrow\) bacterial endocarditis, prosthetic valve dysfunction, aortic dissection
      - since there is no time for LV compensation, there will be flash pulmonary edema
      - classic physical findings will be absent
      - treatment: nitroprusside and surgery
    - if chronic:
      - symptoms of left-sided heart failure
      - increased pulse pressure
        - diastolic murmur: soft, blowing decrescendo at 1st and 2nd pulmonic due to regurgitant spray hitting the bicuspid
          - can cause premature closure of the bicuspid
        - S3 gallop: high pitched at 1st and 2nd pulmonic from changed ventricular compliance
        - Austin Flint murmur: mid-diastolic, low frequency murmur at the apex from regurgitant flow competing with inflow from the left atrium
          - = functional mitral stenosis
        - DeMusset sign: head bob with each heartbeat
- water hammer (Corrigan pulse): radial and carotid pulses are abrupt/distensive with fast collapse
- Traube sign (pistol shot femoral): booming systolic and diastolic sounds heart over femoral artery
- Muller sign: systolic pulsations of the uvula
- Duroziez sign: systolic murmur heard over the femoral artery when compressed proximally, diastolic murmur heard when compressed distally
- Quincke sign: capillary pulsations seen in fingernails or lips
- Hill sign: when the SBP in the popliteal space is > 20 mm Hg higher than brachial SBP

-investigation: same as for aortic stenosis
-treatment:
- meds: vasodilators (ACE or ARB or hydralazine + nitrates) reduce afterload, endocarditis prophylaxis in certain patients
- aortic valve replacement if having symptoms of CHF, if acute with hemodynamic compromise, or if ejection fraction is < 55%

B.) Mitral regurgitation: causes increased end-diastolic vol in LA → dilation of LA to accommodate → increased end-diastolic pressure in LA → backup into pulmonary circulation
-background:
- most commonly due to pathological weakening of connective tissue or mitral valve prolapse
- other causes: ischemic LV dysfunction post MI, dilated cardiomyopathy, rheumatic fever, ventricular dilation, papillary muscle dysfunction, mitral annulus calcification, congenital abnormality, bacterial endocarditis, anorexic drugs
-presentation:
- acute: flash pulmonary edema, cardiogenic shock, new murmur
  - from bacterial endocarditis or other infection, papillary muscle rupture, chordae rupture, necrosis
- chronic: asymptomatic for years, then progressive L heart failure, afib
- holosystolic murmur at apex with radiation to axilla
  - severity of leakage correlated with duration of murmur rather than intensity
  - exaggerate with valsalva
  - decrease with squatting
- soft S1
- S3 often present
- JVD
- laterally displaced apical impulse
-investigation: EKG for LVH, echo, cath to grade severity
-treatment:
- ACEI to reduce afterload
- diuretics
- digoxin
- endocarditis prophylaxis
- if acute → surgery for repair (vs replacement)

C.) Tricuspid regurgitation: failure of the tricuspid valve to close properly during systole → leakage into the right atrium
-background
- can be present in small degrees and be normal
- causes of mod-severe regurg: Ebstein’s anomaly (displacement of valve towards apex), rheumatic disease, carcinoid, endocarditis, trauma from previous surgery
-presentation: symptoms of RV failure
- anasarca (woody looking edema)
- JVD with c-waves & hepatojugular reflux
- pulsatile liver
- holosystolic murmur at left sternal border
  - increases with inspiration
- afib
-treatment: only if severe
-diuretics for R-sided heart failure, digoxin for arrythmias, treatment for pulmonary HTN
-surgery: repair is better than replacement
-prognosis: not good if pulmonary HTN is present

D.) Pulmonic valve regurgitation: the backward flow of blood into the right ventricle during diastole

-background:
- most commonly from dilation of annulus from pulmonary HTN or dilation of pulmonary artery (connective tissue disorder)
- also can be from infective endocarditis or complication from prior surgery
- rarely from congenital malformations, carcinoid, syphilis, or rheumatic fever

-presentation
- can be tolerated asymptotically for many years if it the only defect
- palpable RV heave
- low-pitched diamond shaped diastolic murmur in 1st and 2nd pulmonic spaces
- if there is pulmonary HTN → RV failure symptoms

-investigation: echo → RV-PA pressure gradient > 50 mm Hg
-treatment: balloon valvotomy

☐ Mitral Valve Prolapse: displacement of an abnormally thickened mitral valve leaflet into the left atrium during systole → elongated chordae tendinae

-Background:
- more common in women
- associated with collagen vascular diseases such as lupus, RA, ankylosing spondylitis, Ehler-Danlos, or Marfan’s
- usually presents in young adulthood

-Presentation: most patients are asymptomatic, otherwise fatigue, atypical chest pain, palpitations, anxiety disorders, postural orthostasis, and sympathetic hyperreactivity are common
- others: chest wall deformities, embolic event, bacterial endocarditis, arrythmias
- rarely progresses to mod-severe mitral regurgitation
- mid-systolic click +/- mitral regurgitation

-Treatment: endocarditis prophylaxis, beta-blockers for palpitations, aspirin for clot risk
- surgery if severe (similar criteria to mitral regurgitation, but lower threshold)

Vascular Disease

☐ Aortic Aneurysm: a collection of blood between the vessel layers that causes the area to dilate 1.5+ times greater than normal
- aneurysm could be abdominal, thoracic, at the root, or in the arch
- most commonly below the kidney
- can also have thoracoabdominal aortic aneurysm

A.) Abdominal aortic aneurysm
- background
- normally the aorta is ~ 2cm, it becomes aneurysmal when > 3 cm
- more common in men
- more commonly rupture in COPD patients
- vs pseudoaneurysm: a collection of blood and connective tissue located outside of the vessel wall
- caused by atherosclerosis and inflammation, with genetic/environmental influence
- categorized based on morphology: saccular, fusiform (most common)
- causes disruption of blood flow → prothrombotic state
- rupture of the aneurysm most commonly occurs into the retroperitoneal space but is more deadly when it occurs in the peritoneal space
- 80% mortality with rupture
- risk factors for development: tobacco use, age, HTN, hyperlipidemia, atherosclerosis, male, familial predisposition
- diabetes is protective!
- risk factors for rupture: rapid progression, female, FH, uncontrolled HTN, smoking, COPD
-prevention:
  -USPSTF recommends an US screen in all men age 65-75 who have ever smoked
  -Vascular Consensus Statement: screen all men 60-85, all women 60-85 if they have a cardio risk factor, and both sexes > 50 years old with FH of AAA
-presentation: usually discovered on accident during physical exam, otherwise may have pain in abdomen or back
  -if ruptured → severe pain, palpable abdominal mass, hypotension
-investigation
  -abdominal US
  -CT if US is not informative or pre-op
-treatment
  -endovascular repair
    -stent is placed
    -considered elective in males at 5.5 cm and females at 4.5 cm
    -consider doing earlier if there is rapid expansion
    -indicated for higher risk patients with conducive anatomy (when stent can make it through the groin)
    -unfavorable anatomy may require open surgical repair
  -open surgical repair: aneurysm replaced with graft
    -if not that big, keep watching it and reimage, work on risk factor modification
    -don’t want to surgically intervene too early because the surgery has significant morbidity/mortality
B.) Thoracic aneurysm: further classified as ascending, descending, or arch
  -background
    -much less common than AAA
    -could be ascending or descending thoracic aorta, or arch
      -most to least common: aortic root or ascending aorta, descending aorta, arch
    -spontaneous rupture less common than AAA
    -symptomatic patients have greater chance of rupture
      • ascending thoracic aortic aneurysm: usually due to cystic medial necrosis (elastin degeneration)
        → weakening of aortic wall → formation of fusiform aneurysm
        -often involves aortic root as well → aortic valve insufficiency?
        -cystic medial necrosis may be a normal result of aging but is accelerated by HTN, connective tissue disorders, RA, and bicuspid aortic valve
        -causes other than cystic medial necrosis: vasculitis, syphilis, atherosclerosis
      • aortic arch aneurysm: can be an extension of ascending or descending aneurysm
        -seen with history of trauma or deceleration injury (MVA, hockey, etc)
      • descending thoracic aorta aneurysm: primarily caused by atherosclerosis
    -presentation: most patients asymptomatic at diagnosis
      -potential vascular symptoms: aortic insufficiency, CHF, thromboembolic event
      -potential mass effect symptoms: SVC syndrome (compression from enlargement of aorta), tracheal deviation, cough, hemoptysis, dysphagia, hoarseness
      -steady, deep, severe substernal/back/neck pain
      -excruciating pain if ruptured
        → hematemesis if ruptured into the esophagus
-investigation:
  -CXR → widened mediastinum, enlarged aortic knob, tracheal displacement
  -MRI or CT if negative
  -echo
-treatment:
  -surgeries are much more complicated than for AAA with greater risks, rarely done
  -weigh risk of rupture (increased for Marfan’s or bicuspid aortic valve)
  -when surgery is indicated (gender is not considered in these kinds of aneurysms):
    -ascending aortic aneurysm → 5.5 cm
    -aortic root replacement: Bentall or David procedure (David more common)
    -Marfan’s or bicuspid valve → 5 cm
-aortic valve replacement → 4 cm
-descending aortic aneurysm → 6 cm

☐ **Aortic Dissection:** a tear in the inner wall of the aorta causes blood to flow between the layers of the wall of the aorta, tearing the layers apart and creating a false lumen

- **Background**
  - can be acute or chronic
  - predisposition to tearing with connective tissue disorder, bicuspid aortic valve, or coarctation of the aorta
  - more common in men 60-70 years old
    - but for females there is an increased risk in pregnancy in last trimester
  - often preceded by medial wall degeneration or cystic medial necrosis
  - tear usually goes in direction of blood flow but can go backwards
  - most occur in the ascending or descending aorta, just past aortic valve or at ligamentum arteriosum
  - usually a result of poorly controlled HTN

- **Presentation**
  - acute: sudden, excruciating, “ripping” pain in chest, hyper or normotensive, shock, pulse discrepancy, syncope, acute aortic regurg, focal neuro deficits or CVA due to nonperfusion of brain

- **Investigation**
  - **CXR** → widened mediastinum, left sided pleural effusion, or could look normal
  - **EKG** for LVH or signs looking like inferior MI (cusps associated with dissections are in the same region)
  - **TEE**
  - **acute:** do CT
  - follow up with serial MRA or MRIs

- **Treatment**
  - all pts need aggressive BP control
  - may be based on classification
    - **Debakey classification:** takes into account origin of dissection
      - Debakey I = ascending aorta with extension to the arch and maybe beyond that
      - Debakey II = ascending aorta only
      - Debakey III = descending aorta only
    - **Stanford classification:** more commonly used, doesn’t care about the origin
      - Stanford A = any involvement of ascending aorta
        - go directly to surgery
      - Stanford B = not involving ascending aorta
        - may be medically managed unless there are symptoms of rupture, ischemia, ongoing pain, uncontrolled HTN, or aortic regurg
        - higher mortality procedure
    - chronic or asymptomatic → drugs + yearly re-imaging

☐ **Acute Arterial Insufficiency → Critical Limb Ischemia**

- **Signs of acute arterial occlusion,** the 6 P’s: pain, pulselessness, pallor, paresthesia, paralysis, poikilothermia
- **Causes:**
  1.) traveling embolism from the heart, aorta, or large arteries
    - common in those with afib
    - also from valvular disease, prosthetic valve, ischemic disease
    - rarely from a DVT
  2.) thrombus in situ (clot is formed where it came from): atherosclerotic plaque, trauma, or a result of hypercoagulable disorders

- **Treatment:** revascularization via IV heparin, thrombolytics, surgical thromboembolectomy, or surgical bypass

☐ **Peripheral Arterial Disease:** systemic atherosclerosis distal to the aortic arch

- **At risk:** smokers, diabetics, those with HTN, hyperlipidemia, or those with obesity
- **Presentation:**
  - intermittent **claudication** (cramps induced by exercise and relieved by rest) that is reproducible
    - in buttock, hip, thigh, upper or lower calf, or foot, depending on which artery is affected
  - diminished peripheral pulses
- femoral bruits
- cool skin or abnormal skin color
- poor hair growth (look for those shiny hairless toes!)
- pain at rest, especially at night, due to ischemia
- ulceration or tissue necrosis

-Investigation: must rule out Baker cyst, compartment syndrome, arthritis, nerve root compression, spinal stenosis, and venous claudication

-compare arm BP to ankle BP (ankle/brachial index): take BP measurements all along legs to determine if there is variation in pressures
  - normally ankle SBP should be 10-15 mm Hg higher than arm SBP
  - if ratio is <0.9 $\Rightarrow$ peripheral vascular disease
  - if ratio is <0.7 $\Rightarrow$ intermittent claudication
  - if ratio is <0.4 $\Rightarrow$ patient will have pain at rest
  - if ratio is <0.1 $\Rightarrow$ impending tissue necrosis

- CT to look for vessel narrowing

-Treatment
  - risk factor modification, smoking cessation, walking program
  - antiplatelet therapy to prevent thrombi from the sluggish blood flow
  - revascularization if necessary via open surgery or stent

-Thrombophlebitis: sluggish blood flow causes local thrombosis

- At risk: those with varicose veins, pregnant or postpartum women, pts with blunt trauma, IVs, DVTs, or hypercoagulable states

- Presentation: inflammation, induration, erythema, and tenderness along a superficial vein (usually the saphenous)
  - must be linear vs circular (commonly seen at IV sites, suggests cellulitis)
  - fever and chills $\Rightarrow$ septic phlebitis from IV line

- Treatment: local heat and elevation, bed rest, NSAIDs, anticoagulation of extension into deep veins
  - symptoms resolve in 7-10 days

-Chronic Venous Insufficiency: Varicose Veins

- From incompetent valves in the saphenous veins and branches due to damage or venous dilation

- Presentation: asymptomatic or dull/aching pain in legs that is worse after standing, pruritis
  - may have history of DVT
  - may also see brownish thinning of the skin above the ankles or mild edema

- Investigation: must look for causes such as retroperitoneal venous obstruction, AV fistula, congenital venous malformation
  - rule out CHF, chronic renal disease, decompensated liver disease, lymphedema, autoimmune disorders, or arterial insufficiency from PAD

- Treatment: compression stockings, leg elevation, endovenous ablation, sclerotherapy, rarely greater saphenous vein stripping

- Complications: thrombophlebitis
  - rarely ascends

- Deep Venous Thrombosis: thromboembolism involving the deep veins of the lower extremities or pelvis

- Most frequently in deep veins of the calf

- At risk: those on prolonged bed rest, immobilized pts, airplane travelers, pts with malignancy or nephrotic syndrome or hypercoagulable state

- Prevention: DVT prophylaxis in surgical patients

- Presentation: could be asymptomatic, otherwise aching/dull calf pain that is worse with walking, edema, palpable cord, low grade fever, tachycardia
  - Homan’s sign is + half the time

- Investigation: D-dimer, lower extremity US, VQ if PE suspected, hypercoagulable workup labs

  - diagnose using Wells criteria: score of less than 2 indicates DVT unlikely, > 6 highly likely
  - clinical evidence or PE is #1 suspicion $\Rightarrow$ 3 points
  - HR >100, immobilization or surgery in past 4 weeks, previous DVT or PE $\Rightarrow$ 1.5 points
  - cancer or hemoptysis $\Rightarrow$ 1 point
- Treatment: heparin + warfarin, thrombolytics, embolectomy, IVC filter if pt can’t be on warfarin or has recurrent clots
- Complications: PE, ischemic limb, varicose vein formation, chronic venous insufficiency

- **Giant Cell Arteritis (Temporal Arteritis):** systemic panarteritis affecting medium and large vessels
  - Affected patients are > age 50
  - Presentation: polymyalgia rheumatica, headache, scalp tenderness, visual symptoms, jaw claudication, throat pain, blindness
  - Investigation:
    - sed rates, C-reactive protein, IL-6 \(\rightarrow\) elevated
    - CBC \(\rightarrow\) mild normocytic anemia with thrombocytosis
    - temporal artery biopsy
    - prednisone to prevent blindness
    - watch for thoracic aortic aneurysms (at greater risk from the arteritis)

- **Reynaud’s Disease:** syndrome of paroxysmal digital ischemia caused by exaggerated digital arteriole response to cold or emotional stress
  - Primarily affects young women
  - First pallor then rubor
  - May be primary or secondary to other disease states
  - Presentation: fingers, toes, ears, nose
  - Treatment: Ca channel blockers or nitrate therapy for chronic vasodilation, treat underlying condition

### Myocardial and Pericardial Disease

- **Cardiomyopathy**
  - A.) **Dilated cardiomyopathy:** enlargement of the ventricles
    - Background
      - Most common kind of cardiomyopathy
      - Causes early cardiac dysfunction with gradual development of symptoms
      - Wide variety of causes with a final common pathway
        - From alcoholism (10+ years) \(\rightarrow\) direct myocyte toxicity
    - Presentation: patients are often asymptomatic \(\rightarrow\) incidental finding on routine physical exam
      - LV dysfunction \(\rightarrow\) exercise intolerance, fatigue, weakness, dyspnea, systemic and pulmonary congestion
      - Symptoms of R-sided failure are a late finding with poor prognosis
      - Chest pain from ischemia or decreased coronary reserve
      - Cardiomegaly \(\rightarrow\) displaced apex with enlarged PMI
      - Normal or low BP with decreased pulse pressure
      - May hear S3
      - Systolic murmur because dilated heart chambers pull on valves and don’t allow them to close all the way \(\rightarrow\) secondary mitral or tricuspid regurg
    - Investigation:
      - Electrolytes, thyroid function tests, sed rates, antinuclear antibody, ferritin, HIV test
      - CXR
      - EKG for sinus tachycardia, interventricular conduction delays, Q waves
      - Echo: ejection fraction, wall motion abnormalities/ischemia, underlying valvular disease
        - Use findings to rule out pericardial disease
      - Cardiac cath: to do coronary angiogram, assess pressures, maybe do a biopsy
      - Cardiac MRI: good information about infiltrative processes
    - Treatment: identify and treat the correctable cause of the cardiomyopathy
      - Alcoholic toxicities can be reversible
      - Heart failure symptoms: salt and fluid restriction, vasodilators, beta blockers, diuretics
      - Arrhythmia management: ICDs
      - Eval for transplant
B.) Hypertrophic cardiomyopathy: a result of inappropriate hypertrophy of the septum with disorganized muscle bundles → hypercontractility of LV with reduced ventricular volume, fibrosis of tissue
- background:
  - hypertrophy unrelated to valvular disease or HTN
  - can be asymmetric or global enlargement of the septum (or apex if Japanese)
  - abnormal thickness and arrangement of wall muscle puts pt at risk for electrical dysfunction
  - in many HCM patients there is obstruction to outflow of blood from LV (dynamic outflow obstruction)
    - usually due to abnormal changing of pressure gradient during systole due to systolic anterior motion of the mitral valve (SAM, a kind of backwards mitral prolapse) → LV must build up more pressure to overcome the regurg → increased O2 demand with increased filling pressures
  - most commonly in men ages 30-50
  - can be familial
  - risk of sudden death is higher in <30-35 year olds due to arrhythmias
  - can progress to dilated cardiomyopathy
- presentation: clinical deterioration is slow, most are asymptomatic or only mildly symptomatic
  - dyspnea, angina, fatigue, syncope, afib
  - patients without gradient will have minimal findings: LV lift, S4
  - patients with established outflow obstruction: forceful/displaced apical impulse from thickened muscle, systolic thrill, S4, harsh crescendo systolic murmur +/- mitral regurg murmur
- investigation:
  - must distinguish from aortic stenosis!
    - Valsalva will increase the murmur of HCM while it will decrease the murmur of AS
  - carotid pulses will be brisk with mid-systolic decline in HCM while they are always sluggish in AS (parvus et tardus)
- labs:
  - EKG → LVH, ST/T changes, giant T wave inversion (Japanese apical), Q waves
  - echo → LVH, asymmetric septal hypertrophy, outflow obstruction with SAM/dynamic pressure gradient
  - cardiac cath to evaluate gradient
- treatment: manage symptoms
  - beta blockers for angina, dyspnea, pre-syncpe
    - reduce outflow obstruction during exercise
    - reduce O2 demand
  - Ca channel blockers to reduce contractility, decrease outflow gradient, improve diastolic relaxation, and increase exercise capacity
  - treat tachyarrhythmias: pacemaker or AICD
  - surgical strategies: myectomy or mitral valve surgery, percutaneous ethanol ablation (inject alcohol into thickened septum to kill it)
  - transplant for those with LV dilation
C.) Restrictive cardiomyopathy: abnormal diastolic function → normal contractility but rigid and stiff ventricular walls
- background:
  - a result of an infiltrative process such as amyloid (deposition of abnormal heart proteins), hemochromatosis, sarcoidosis, eosinophilic disease, or glycogen storage disease
  - infectious cause: HIV poor prognosis
- presentation: signs of R-sided heart failure predominate
  - diastolic resistance to filling → pulmonary pressures must increase to deliver blood → pulmonary HTN → wearing out of right atrium

☐ Myocarditis: inflammatory process of the heart
- Background:
  - most commonly due to infection
  - can also be from allergic reactions, drugs, inflammatory illness, toxins (cocaine)
  - mechanisms: straight-up invasion of the myocardium, deposition of toxins, or autoimmune attack
-can be a cause of idiopathic cardiomyopathy

-Presentation: anywhere from asymptomatic to fulminant heart failure
- chest pain, pericarditis, displaced PMI
- tachycardia out of proportion to fever

-Investigation:
- EKG → ST/T wave abnormalities
- echo → LV dysfunction
- labs: viral serologies, viral culture of stool/throat/pericardial fluid
- endocardial MRI to confirm myocarditis

☐ Pericardial Diseases
A.) Acute pericarditis: acute inflammation of the pericardium
- background:
  - idiopathic or viral
  - can be caused by MI, any kind of heart surgery, TB, neoplasm, or trauma
  - tissue has increased vascularity with fibrous adhesions and exudate
- presentation:
  - chest pain: pleuritic, hard to distinguish from ischemia, aggravated by laying down
  - pericardial friction rub: pre-systolic, ventricular systolic, and early diastolic
  - dyspnea from chest pain
  - symptoms of underlying illness
- investigation:
  - serial EKGs → diffuse ST elevation with inverted T waves, then return of ST to baseline with flat T waves, then T wave inversion, then normal T waves
  - may also have PR depression
  - labs: inflammatory markers, myocardial markers
  - echo for effusion
  - pericardiocentesis for patients with tamponade
  - biopsy?
- treatment: treat underlying cause
  - watch for development of tamponade
  - pain relief: bed rest, NSAIDs, aspirin, corticosteroids, colchicine
  - antibiotics +/- drainage
  - IV anticoagulants
- prognosis: usually self-limiting, some can have recurrent symptoms (give chronic colchicine therapy)

B.) Hemorrhagic pericarditis: usually caused by TB
C.) Purulent pericarditis: usually caused by Staph aureus or Strep pneumoniae
- cause: spread via blood or endocarditis, post-op infection

D.) Post-infarction pericarditis: from local inflammation
- causes pain for 1-6 weeks
- may hear friction rub even without pericarditis
- discontinue anticoagulation therapy if effusion develops
- treat with high dose aspirin (avoid NSAIDs and corticosteroids)
- symptoms can often blend with Dressler’s syndrome: malaise, fever, pericardial discomfort, effusion, leukocytosis post-MI
  - unknown cause, maybe autoimmune
  - same treatment as post-MI pericarditis
E.) Neoplastic pericarditis: frequently from lung cancer, breast cancer, leukemia, or lymphoma
- nodular tumor deposits in pericardium from hematogenous or lymphatic spread
- often asymptomatic

F.) Cardiac tamponade: increase in intrapericardial pressure secondary to fluid buildup
- background:
  - causes diminished distension of chambers in diastole → decreased stroke volume
  - initial circulatory compensation with progressive decline
  - can be caused by any kind of pericarditis or effusion but most common in malignancy
- presentation:
- **Beck’s triad**: hypotension (heart not filling properly), elevated venous pressure (increased pericardial pressure transferring to neck veins), muffled heart sounds due to increased fluid
  - also dyspnea, weakness, stupor, chest pain
  - elevated JVP, tachypnea, tachycardia, friction rub, pulsus paradoxus (BP variation)

- **investigation**:
  - CXR → heart may look large but otherwise no characteristic changes
  - EKG → findings associated with acute pericarditis or effusion
    - **electrical alternans**: QRS keeps changing axis because there is so much fluid sloshing around
  - echo
  - cardiac cath

- **treatment**: volume resuscitation, pericardiocentesis, pericardial window

G.) **Constrictive pericarditis**: thick, fibrotic pericardium restricts diastolic filling

- **background**:
  - constriction is symmetric → equalization of pressures throughout chambers
  - rapid early diastolic filling with limited late diastolic filling
    - no kick → reduced stroke volume
  - can be caused by progression of acute pericarditis to fibrous scarring
  - otherwise idiopathic, connective tissue disease, post-op, ESRD, post-radiation

- **presentation**:
  - Kussmaul’s sign: normal variance in pressures during breathing don’t occur because the heart is so encased → steady or rise in JVP
    - also occurs in restrictive cardiomyopathy but not in tamponade
  - systemic congestion → hepatosplenomegaly, ascites, edema, pulmonary congestion
  - may hear pericardial knock in early diastole
  - no palpable apical impulse
  - no S3
  - may have pulsus paradoxus

- **investigation**
  - CXR
  - EKG → may be low voltage
  - echo → effusion
  - cath

- **treatment**: pericardial stripping (pericardium peeled away from the heart)

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**Arrhythmias**

- **Atrial Fibrillation**

  - **Investigation**
    - 12 lead EKG
    - CXR
    - echo
    - thyroid panel
    - Holter monitor or stress test

  - **Treatment**
    - hemodynamically unstable → cardiovert
    - borderline stable → gentle rate control with IVF support
    - stable:
      1.) rate control: target this vs rhythm for less mortality
        - not always tolerated in patients with cardiomyopathy or diastolic dysfunction (lose atrial kick)
        - goal is < 110 during normal activity
        - 1st choice is beta blocker
        - 2nd choice is Ca channel blocker
        - digoxin only works at rest
2.) anticoagulation: weigh risk of stroke vs bleeding with CHADS2 score
3.) cardioversion: electrical vs chemical
   - only considered for symptomatic patients that can’t tolerate it, or those with first or sporadic episodes
   - with onset < 48 hours can go right to cardioversion
   - if ? onset or > 48 hours → TEE before any cardioversion attempt
   - warfarin for 4 weeks post cardioversion
   - drugs post cardioversion to maintain sinus rhythm

- Atrial Flutter
  - Does not respond as well to rate or rhythm control drugs
  - Stroke risk not as high as with afib
  - First line treatment in symptomatic patients is ablation

- Supraventricular Tachycardia
  - If not sinus, then it is
    a.) AV nodal reentry tachycardia: most common kind, round-and-round circle
      - P’s buried in QRS
      - brief episodes
      - long-term control with beta blockers or Ca channel blockers
      - ablation of slow pathway is treatment of choice
    b.) AV reentry tachycardia: retrograde conduction via accessory pathway
      - P’s after QRS
      - commonly occurs with Wolf-Parkinson-White
      - DO NOT GIVE typical rate control meds as they preferentially slow the AV node and may promote aberrant rhythms to be conducted down the accessory pathway!
        = give procainamide until pathway is ablated
    c.) junctional tachycardia