L01 Heart Failure:

Left sided HF → SXS: dyspnea, orthopnea, PND, fatigue → PE Findings: tachycardia, tachypnea, Rales (pulmonary edema), loud P_2, S_3 gallop, S_4 gallop

1. impaired contractility from CAD
2. chronic volume overload
3. DCM
4. arrhythmia

→ systolic dysf(x) → eccentric hypertrophy?? low BP, poor perfusion of end organs (Not pumping)

→ diastolic dysf(x) → flash edema (Not filling)

Dilated Cardiomyopathy = dilates every part of ♡. Not just LV...
- ∅ primary valvular abnormalities or CAD
- drugs (doxorubicin / daunorubicin) → vacuolization of myocytes
- autoimmune → autoantibodies to myosin light chain, tropomyosin, g-actin
- autosomal dominant mutations (MC) → cardiac cytoskeleton, TTN
- X-linked recessive mutations → dystrophin
- peripartum DCM → antiangiogenic mediators, ↓VEGF

Hypertrophic Cardiomyopathy

1. LVH (aortic stenosis / HTN)
2. cardiac tamponade
3. Hypertrophic or restrictive cardiomyopathy
4. myocardial fibrosis

Right sided HF → peripheral edema, RUQ pain → (blood backs up in venous system) edema, JVD, Hepatomegaly → passive congestion = "Nutmeg Liver"

1° pulmonary dz → cor pulmonale
- COPD
- chronic thromboembooli
- pulmonary stenosis

Stage	ACCF/ AHA Stages of HF	Class	NYHA Functional Classification
A	At high risk without structural heart disease or symptoms of HF		None
B	Structural heart disease without sign or symptoms of HF	I	Cardiac disease, but no symptoms and no limitation in ordinary physical activity
C	Structural heart disease with prior or current symptoms of HF (structural ∱ symptoms) (ACE I)	I	Cardiac disease, but no symptoms and no limitation in ordinary physical activity
		II	Slight limitation during physical activity due to mild symptoms (fatigue, palpitation or dyspnea). can't walk @ Walmart
		III	Significant limitation in activity due breathlessness, fatigue, or palpitation. Comfortable only at rest. SOB going to RR
		IV	Unable to carry on any physical activity without discomfort. Symptoms at rest. Bedridden
D	Refractory HF		

HF Drugs:

★ HF regimen: ACE-I + Beta Blockers

↓ PRELOAD (decreasing amount of blood in the body by diuresing)

★ **Loop Diuretics** - Furosemide, Torsemide, & Bumetanide
- for pts w/ symptomatic overload
- careful of electrolyte abnormalities
- ★ NSAIDs decrease response of loop-diuretics due to ↓RBF

★ **Thiazide Diuretics** Metolazone / HCTZ - need good renal filtration to be effective [sCr<2 GFR>30]
- ineffective as monotherapy in HF
- ★ NSAIDs decrease response

★ **Aquaretic** TOLVAPTAN - inhibits V2 receptor, ↑H_2O excretion; ↓Edema
- ★ Rapid correction results in HYPERNATREMIA ★★ WBOT → Monitor Na^+ levels

DIURETIC THERAPY CAN DECREASE C.O. → WORSENS HF

TQ

★ Aldosterone antagonists: spironolactone & eplerenone
★★ DECREASE MORTALITY via inhibition of collagen deposition
s/e: Hyperkalemia

Use:
- "Go to drug in Hypertension" ★★
- Ineffective as mono therapy in HF ★
- Administered with Loop Diuretics in patients who do not achieve adequate diuresis

Electrolyte disturbances
- Hypokalemia
- Hyponatremia
- Hypercalcemia
- Hyperuricemia (may result in Gout) ★
- Hyperglycemia
- Contraction alkalosis

THIAZIDES

Adverse Effects:
- Use only in patients with Scr < 2mg/dL or GFR > 30ml/min — if GFR<30, thiazides won't work, use LOOP!
- NSAIDs can decrease the response to thiazide-diuretics due to decreased RBF

Diuretic therapy must be used judiciously because over diuresis can result in ↓CO, renal perfusion, and symptoms of volume depletion — can worsen HF

TQ

↓ AFTERLOAD (decreasing amount of force necessary to pump blood)

★ ACE-I: ↓mortality, ↓preload AND afterload
★ ARBs: less angioedema, less cough
★ β-Blockers: Bisoprolol, Metoprolol, carvedilol
↓mortality, Negative inotropy
Ø use in decompensated HF or 2°/3°HB
↓HR = ↑diastole ∴ more efficient?

★ Vasodilators:

HFrEF

★ Isosorbide dinitrite/hydralazine = vaso/venodilators
★★ DECREASE MORTALITY in AA when used w/ ACE-I/β-blockers
- Hydralazine → Lupus-like syndrome (SHIP)

★★ WBOT in pts w/

★ Sacubitril inhibits Neprilysis, ↑ANP/BNP
- given w/ ARB (valsartan)
↳ Entresto → used in class II-IV in place of ACE/ARB

INOTROPES

★ Digoxin inhibits Na/K ATP-ase ∴ ↑Ca^{2+} intracellularly ∴ ↓HR, ↑C.O., ↓O_2 demand
★★ HYPOkalemia = ↑dig binding → causes toxicity → blurred/yellow vision + vent. arrhythmias (DAD)
" pt taking loop diuretics or Ca^{2+} supplement"

★★ WBOT

★ Dobutamine stimulates $\beta_1 > \beta_2, \alpha_1$ — SHORT TERM

★ Milrinone inhibit PDE 3 in heart = ↑C.O.
↳ ↑cAMP, ↑Ca^{2+}
+ peripheral venous dilation = ↓SVR & wedge pressure ★

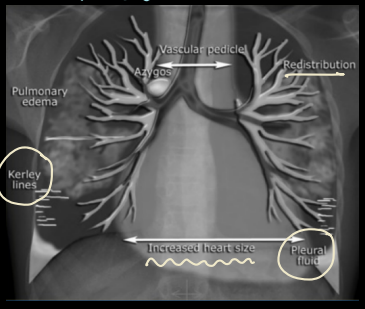
⊕ inotropes used in decompensated HF

L04 Clinical Heart Failure

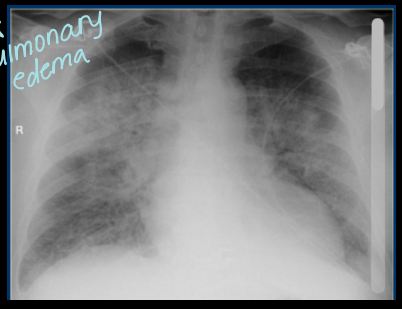
Systolic HF: weak LV = impaired pumping
- caused by MI, chronic overload, valvular dz, DCM, arrhythmia

Diastolic HF: impaired filling
- caused by LVH, HCM, restrictive cardiomyopathy, fibrosis, tamponade
↳ know what it looks like on EKG → also Afib

★ LEFT-sided HF:
- sxs: fatigue, palpitations/tachycardia, pulmonary edema → SOB, weight gain
- PE: S_3 = systolic failure
S_4 = diastolic failure
Rales + abnormal CXR →
  - redistribution of vasculature
  - Kerley B lines
  - pleural fluid



★ pulmonary edema



RIGHT-sided HF:

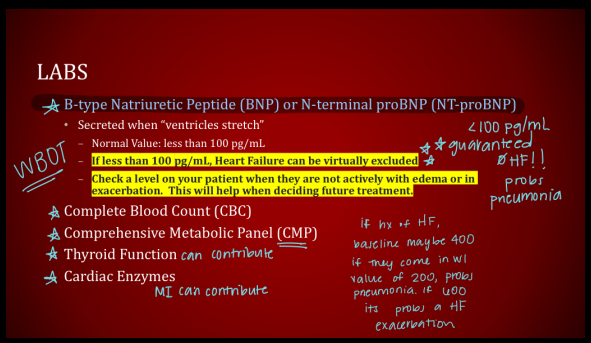
- sxs: fatigue, palpitations/tachycardia, vascular congestion → peripheral edema
- PE: peripheral edema, Hepatomegaly
  - → Pitting edema @ lowest point aka nips for bedridden lady

peripheral edema
JVD, weight gain, frequent urination

HEART FAILURE LABS:

WBOT

- BNP: secreted when ventricles stretch
  - if <100 pg/mL → HF can be ruled out
  - if pt Hx of HF baseline is 400:
    - if they have BNP of 200 → pneumonia
    - if they have BNP of 400 → HF exacerbation



HF DRUGS:

- ACE-I/ARBS ↓ mortality
  - COMPLETE CONTRANDICATION IN PREGNANCY
    - -document counseling in fertile females

WBOT

- Beta-blockers ↓mortality
  - avoid in diabetics (masks hypoglycemia), decompensated HF, & asthmatic pts/COPD
- Peripartum cardiomyopathy → Metoprolol

STAGING

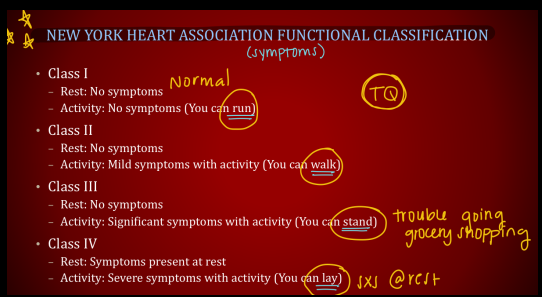
- ECG, echo, ANP/BNP levels, CXR, stress test

Stage A: high risk but ∅ structural abnormalities & ∅ sxs
- lifestyle changes
- tx @ risk condition

Stage B: structural Heart dz but ∅ sxs
- modify risk factors
- ACE-I/ARBs/β-Blocker
- NO CCB! ∅ VD

Stage C: structural heart dz w/ current or previous sxs
- control sxs
- ACE-I/ARB + B-blocker + aldo antag.
- maybe add'l meds or AICD

Stage D: refractory HF - likely bedridden
- decrease sxs, end of life care, etc.



Decompensated HF: significant SDB, swollen potato, SpO_2 80% → HOSPITAL
- caused by acute event like thromboembolism, valvular dysf(x), MI

Tx: Dobutamine
vasodilators
loop diuretics

Pacemaker placement if EF < 35% & LBBB → restore synchrony

ICD → prevents sudden cardiac death from Vtach/Vfib
→ MI >40days ago, EF < 30%, or risk of arrhythmia

L05 Cardiomyopathy

beta-myosin heavy chain

★ **Hypertrophic Cardiomyopathy (HCM)** = **autosomal DOMINANT** changes in sarcomere **MYH7**

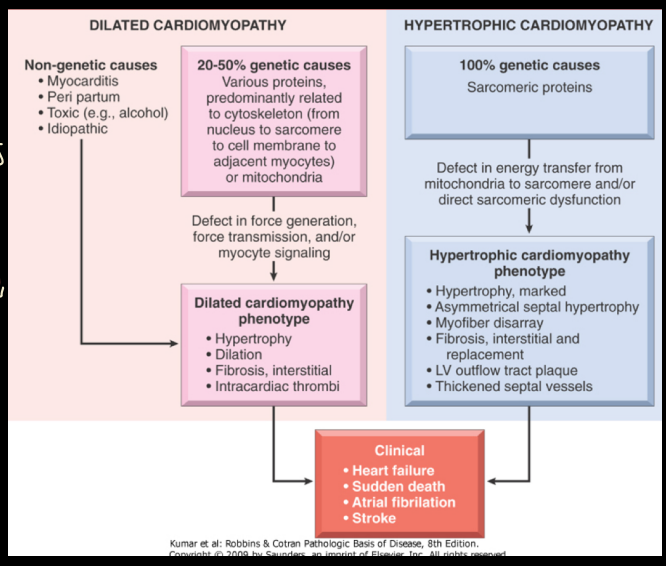
- can't fill → sudden death, syncope, CP on exertion
- ★ Normal PE or S4 + **systolic cresc./decres. murmur @ LLSB**
- ★ Dx w/ **ECHO** showing thick septum
- ★ on EKG - could be normal
  - dagger Q waves ★
  - WPW
  - AFib
- ★ Tx: Beta Blockers, maybe ICD
  NO physical activity (sports)

- An inheritable autosomal dominant disease of the heart that is characterized by marked hypertrophy of the myocardium with myofibril disarray and small left ventricular cavity with or without ventricular outflow obstruction.

★ **Dilated Cardiomyopathy (DCM)** = ALL FOUR CHAMBERS

- ★ Genetic
  - ★ A. Dominant (MC) - multiple genes for:
    → cardial cytoskeleton, myofibrillar & nuc. membrane proteins
  - ★ X-linked recessive - dystrophin gene
- ★ Pregnancy
- ★ Alcohol - bivent. dilation; >90g daily ≥5 years
- ★ Viral (CoxB)
- ★ autoimmune - ab against tropomyosin, MLC, &actin
- ★ drugs (doxorubicin) - cancer patient

TQ: thiamine deficiency → wet beriberi get accurate soc hx



SxS: SOB, edema, fatigue
Dx: Hx/PE + ECHO (biopsy Ø needed)
Tx: ↓NaCl, Diuretics + ACE-I/ARBs + Bblockers

TQ ★ Pt presents 38wk gestation, SOB, spO_2 80%, edema, CXR shows cardiomegaly, EKG shows AFib
→ GIVE HER METOPROLOL ★

★ **Tachycardia induced cardiomyopathy** → Length of time > rate

★ **Stress-induced cardiomyopathy (Takotsubo)** = APICAL BALLOONING
- due to catecholamine surge

★ **Restrictive Cardiomyopathy (HFpEF)** = amyloidosis, sarcoidosis, etc.

caution! looks similar to constrictive

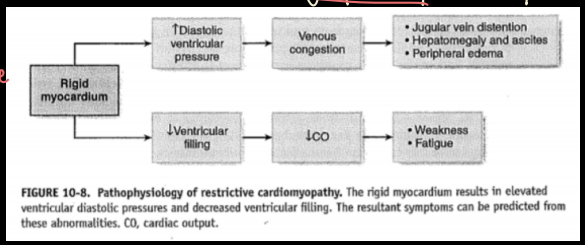


FIGURE 10-8. Pathophysiology of restrictive cardiomyopathy. The rigid myocardium results in elevated ventricular diastolic pressures and decreased ventricular filling. The resultant symptoms can be predicted from these abnormalities. CO, cardiac output.

→ characterized by:
- kussmaul's sign: JVD worse w/ inspiration
- ↓C.O.
- L&RV effected → bivent. failure

PATHOLOGY:

LO1 CHF

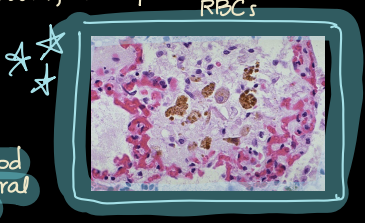
Left HF

- **Systolic HF** ↓EF (<40%) → poor organ perfusion & pulmonary edema
  - caused by HTN, valvular dz, arrhythmias (Afib/AV blocks)
  - ★S3 gallop, large dilated heart
  - → Pre-renal azotemia, cerebral hypoxia
- **Diastolic HF** Normal EF (>50%) → fatigue, FLASH Pulmonary edema
  - caused by stiff LV from alute ischemia (rigor mortis), restrictive dz/amyloid/sarcoid, obesity
  - ★S4 gallop

Pulmonary Edema

↑ Hydrostatic pressure in lung capillaries

TQ: ★SOB, orthopnea & PND → HEART FAILURE CELLS ★★ - Hemosiderin laiden MØ bc they ate RBCs



chronic L HF causes RHF

Right HF can be caused ACUTELY by PE, chronically by LHF (MC), cor pulmonale, Pulm HTN, pulmonic stenosis

→ peripheral edema, JVD, & Passive hepatic congestion ★★ NUTMEG LIVER (pools blood near central vein)

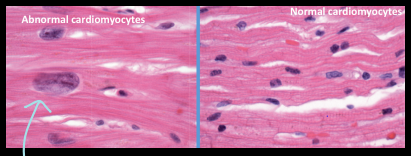
TQ

→ Compensatory Mechanisms:

1. Frank Starling: ↑volume ↑stretch & contractility to ↑SV → decompensates eventually
2. Ventricular remodeling: cardiomyocyte hypertrophy wl or wlo dilation
   - ★INITIALLY ENHANCES FUNCTION★ → ultimately contributes to failure
   - → ↑myocyte size W/O ↑ blood supply → Prone to ischemia! ↑O_2 ★★ demand

reminder: cardiomegaly is an independent risk factor for sudden death

1. Eccentric Hypertrophy – dilation due to volume overload
   - chronic aortic or mitral regurg
   - sarcomeres in SERIES, decreases diastolic tension



2. Concentric Hypertrophy – Ø dilation, hypertrophy due to pressure overload
   - chronic HTN, aortic stenosis
   - sarcomeres in PARALLEL, decreases systolic wall tension

Hypertrophy → BOXCAR NUCLEI

TQ: TDNA ploidy from Treplication in absence of cell division

3. Neurohumoral stimulation in response to ↓CO
   - Norepi tries to ↑HR in effort to ↑blood flow
   - RAAS tries to reabsorb Na^+/H_2O to ↑EABV
   - ADH "
   - Endothelin vasoconstricts to try to ↑ perfusion

NOT HELPFUL

TQ?

★ANP/BNP increase in response to stretched chambers → Naturesis

actually helpful

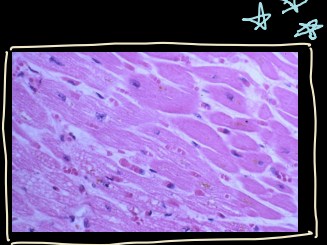
LO2 cardiomyopathy

DING DING

MC ★ **Dilated Cardiomyopathy**: Large heart wl dilation of ALL FOUR CHAMBERS → death by thromboemboli, arrhythmias, & heart failure

★ Ø primary valvular dz or CAD

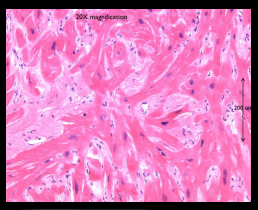
- Genetic: ①Autosomal dominant – cardiac cytoskeleton, nuc. membrane → TTN
  - ★②X-linked dystrophin mutation
- Autoimmune: antibodies to myosin light chain, tropomyosin, actin → triggered by COXB?
- Alcoholic: dx of exclusion >90g /day for 5yrs → thiamine deficiency = Wet beri-beri
- TQ ★★ Drugs: ANTHRACYCLINE DRUGS = doxorubicin & daunorubicin = chemo drug
  - → peroxidation of lipids → vacuolization of cardiomyocytes →
- TQ ★★ Peripartum: ↑in African Americans, late in pregnancy or 5mos after
  - → antiangiogenic mediators cause DCM (Ø VEGF)



★ Hypertrophic Cardiomyopathy: Auto. Dominant missense mutation of sarcomere proteins → ★ Myosin binding protein C, Beta myosin heavy chain

★ asymmetric septal hypertrophy → small LV cavity + thick ant. mitral leaflet ★

TQ



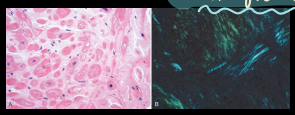
px: syncope, angina, dyspnea, sudden death + S4 (stiff ventricle)

→ disarray / disorganized fibrosis

→ LV outflow obstruction! = venturi effect

★ Restrictive cardiomyopathy: R & L ventricles affected → signs of (R) & (L) Heart Failure, Kussmaul sign (+)

★ Amyloidosis → pathologic protein deposition



TQ

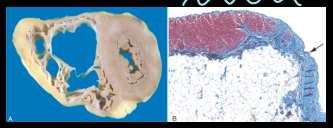
★ SENILE CARDIAC AMYLOIDOSIS = TRANSTHYRETIN ★ ★ transports retinol & thyroxine; ISO → val substitution in AA = auto dom

★ congo red stain → apple green birefringence

★ Sarcoidosis → NONcaseating granulomas (lung, lymph nodes, skin, eyes)

- GIANT cells, Schaumman's bodies

★ ARVD → thinning RV w/ fatty & fibrofatty replacement + aneurysm formation



mutation in desmoplakin & plakoglobin → DESMOSOMES ★★ = Uhl's anomaly

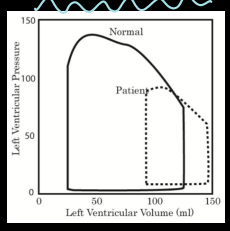
---

LOW SHOCK = inadequate tissue perfusion relative to metabolic demand

Heart Failure is caused by:

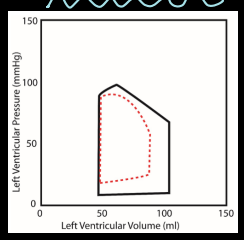
1. contractile defects → MI, SLE, toxins
2. overload → regurgitation, stenosis, HTN, thyrotoxicosis
3. impaired filling → mitral stenosis, pericarditis, infiltrative dz

SYSTOLIC HF

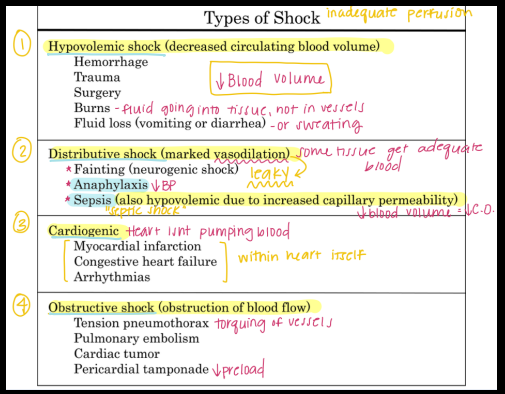


FLOPPY
↓SV
↑preload
↑EDV

DIASTOLIC HF



Ø FILLING
↓SV
↓preload
↓EDV

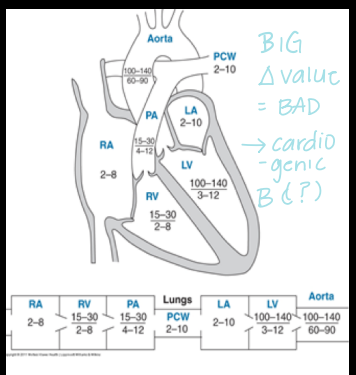


Cardiogenic shock: commonly assoc. w/ HF / loss of LV contractility

Sxs resemble hypovolemia but preload is INCREASED (WBOT) ★★

→ JVD, HJ reflux, pulmonary edema

→ LACTIC ACIDOSIS, cold clammy skin, rapid pulse



BIG Δ value = BAD → cardiogenic B(?)

Extrathoracic / Obstructive shock: ① impaired diastolic filling ② ↑afterload

= tamponade, tension pneumo, pericarditis ★★ → physically obstructing

Hypovolemic shock:

↓preload, ↓RBF & GFR → prerenal AKI → ATN (muddy brown casts) + azotemia & oliguria

→ LACTIC ACIDOSIS, cold clammy skin, rapid pulse

↑ sign of organ damage!

★ severity associated w/ magnitude of loss and RATE

TQ ★★ AFTER 2HR - MAY BE IRREVERSIBLE

↓TPR

Distributive shock due to extreme **vasodilation** → LEAKY - includes **SEPTIC SHOCK**, **ANAPHYLAXIS** & **NEUROGENIC**

TQ

★ SKIN IS WARM - blood flow diverted to skin

★ epi helps by ↑TPR bc agonist → vasoconstricts

★ ↑HR, ↓duration of diastole → cardiac ischemia

★ Anxiety induced tachycardia → press on carotid body to activate PSNS

due to decreased peripheral vascular resistance

DING DING DING

★ **Septic shock** due to toxic microbial products → **VASODILATION** = [hypotension that requires pressors & lactate > 2]

TQ

- toxins can also induce cardiogenic shock

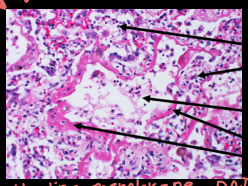
★ Most common cause of death in ICU - especially strep A TSS (Ø septicemia)

★ skin is warm & appears flushed due to vasodilation = **DECREASED PVR!!**

TQ

- causes: - gram ⊖ bacteria, viruses, fungi PAMPs binding to TLR on WBC → INFLAMMATION + complement + coagulation
- results in: ①↑vasc. permeability ②vasodilation ③thrombosis
- Metabolic abnormalities: ①Hyperglycemia ②insulin resistance ③Adrenal insufficiency ④Lactic Acidosis

Waterhouse Freidrich syndrome



Hyaline membrane = DAD

★ ARDS

1. endothelial activation
2. NETs ↑inflammatory mediators
3. injured endothelium/pneumocytes → HYALINE MEMBRANE FORMATION (DAD)
4. resolution - type II regenerate

TQ

★ DIC = fibrinolysis + coagulation → infarct adrenals = waterhouse freidrich syndrome

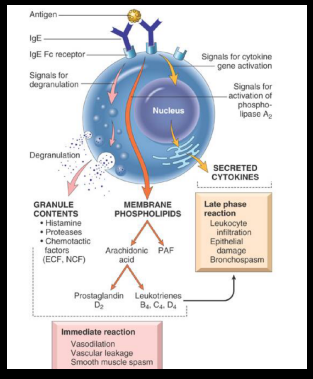
→ BLEEDING!

★ **Anaphylactic shock** type I hypersensitivity rxn

set up: naive $T_H \rightarrow TH2$

[①immediate rxn (5-30min) vasodilation, sm. muscle spasm, glandular secretions
②late phase (2-24 hrs later) = destruction of mucosal epithelium EOSINOPHILS]

preformed ★ [Histamine & Leukotrienes]



★ LOT Path of Shock

Stages of shock:

① initial nonprogressive stage: trying to compensate
- Neurohumoral mechanisms ★ FIRST THING
px: tachycardia, peripheral vasoconstriction
★ perfusion to organs MAINTAINED

② Progressive stage:
- tissue hypoxia → Lactic acidosis ★
- endothelial anoxic damage → DIC ★

③ irreversible stage:
- widespread, ↓contractile f(x) of heart, bowel ischemia

Difference in septic versus low cardiac output shock etiology

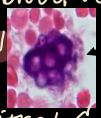
- In septic shock (normal or high cardiac output state), the inflammatory cascade induced by microbes is the initiating event causing shock with decreased peripheral vascular resistance.
- In low cardiac output shock (hypovolemia, cardiogenic, etc.), an inflammatory cascade/DIC may occur but this is an end stage result due to tissue damage from ischemia caused by the shock state.

TQ

L09 Path: Heart & Systemic DZ

★ **Lupus** : antibodies to **dsDNA & Sm antigen**

- **Pericarditis** → serous, fibrinous, or serofibrinous - pleuritic chest pain, friction rub (fibrinous)
- **Myocarditis** → immune complex deposition in & around blood vessels → inflammatory rxn + complement
  - ★ Lymphocytic infiltrate + hematoxylin bodies



TQ

- **valvulitis** →
  - ★ **Libman Sacks** → fibrinoid necrosis of mitral & tricuspid on **BOTH SIDES** ★★
    - → **antiphospholipid syndrome** → thrombotic lesions

- **congenital HB in neonatal Lupus**
  - ★ autoantibodies passively cross placenta → irreversible damage to fetal conduction system
    - TQ
    - ★ Heart Block in utero

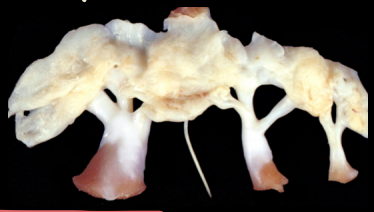
★ **Thyroid Disease** → **T3** ↓SVR, ↑HR, ↑contractility, ↑BV

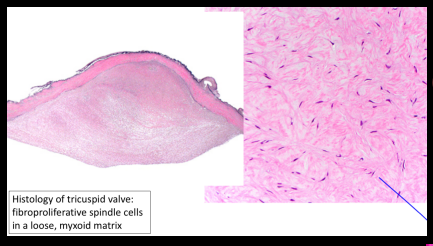
- **Hyperthyroidism**
  - New onset **AFib**, LVH, exercise intolerance
  - ★ Hypertrophy
- **Hypothyroidism**
  - bradycardia, diastolic HTN, atherosclerosis, CAD
  - ★ flabby, enlarged, dilated
  - ★ myofiber swelling, interstitial **mucopolysaccharide deposition** = ★ **MYXEDEMA HEART**

★ **Carcinoid Heart Disease** → **Neuroendocrine tumor releases serotonin**

- ★ tumor in GI **w/ metastasis to liver** OR **Lung tumor** = **CARCINOID SYNDROME**
- ★ plaque-like thickening of right-sided heart valves → **TRICUSPID INSUFFICIENCY**

phen-phen
ergot drugs →



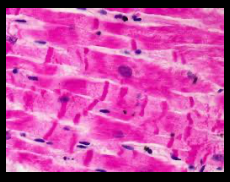


TQ

acid mucopolysaccharide

★ **Catecholamine toxicity**

- ★ **Acute** = **contraction band necrosis** → direct myocardial toxicity, hypoxia (↑O_2 demand)



- ★ **Chronic** = fibroblasts activated via β_2 adrenergic stimulation

Ex: **Takotsubo** - APICAL ballooning

Cocaine - inhibits reuptake of catecholamines

★ you don't need to OD to die from cocaine → **Ischemic heart damage**

L10/11 Pulmonary HTN

- Class I doin' fine can run
  - No limitation with functional activity
- Class II
  - Comfortable at rest but has slight limitation with activity can walk
    - Shopping, climbing stairs, or making the bed
- Class III
  - Comfortable at rest but has significant limitation with activity can stand
    - Activities of daily living such as dressing, bathing, toileting, or transfers. ADLs affected
- Class IV
  - Symptoms at rest. Signs and symptoms suggestive of right sided congestive heart failure. can lay

★ Mechanism of pulmonary HTN = ↑pulmonary vascular resistance

★ Ortner's syndrome - damage to left recurrent laryngeal nerve → Hoarseness

★ loud, wide split S2 + tricuspid regurgitation

★ look for sleep apnea ★

★ CBC - check ↑Hb due to hypoxia

★ ECG findings RBBB, Right axis deviation, peaked p-waves

★ PFT normal but ↓DLCO

★ Big pulmonary artery on CT

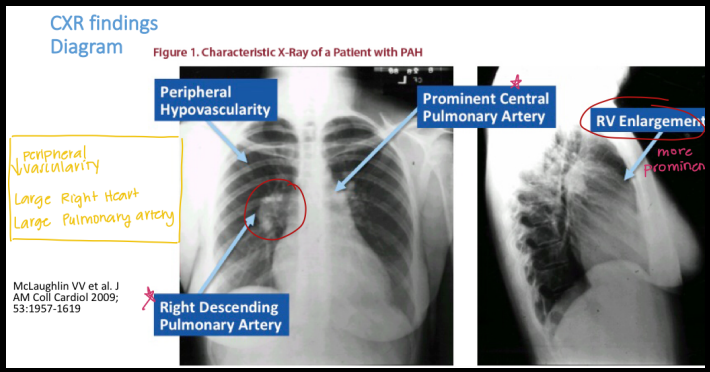
★ Dx: Right Heart Cath >25mmHg ★

★ ↓mean pulmonary artery pressure ↓10 mmHg

TQ

PAP ↓ by 40mm Hg → ØΔ in C.O.

→ Tx w/ CCB — Nifedipine ★ or diltiazem



★ cGMP PDE5 inhibitors (-afil) = Group 1A PAH

★ guanylate cyclase stimulator = Group 4

★ Prostacyclins = Group 4

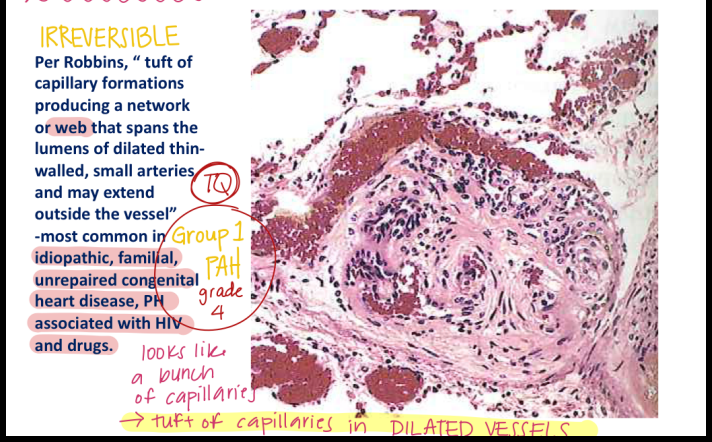
★ DO NOT USE VASODILATORS IN GROUP 2 or 3 ★ ★

PATHOLOGY

★ Endothelial injury/dysfunction
→ pulmonary vasoconstrict
→ thrombosis
→ TECM = ↑wall thickness

- Group 1:
  - ★ Familial form = BMPR2 gene mutation inhibits apoptosis
  - ★ Schistosomiasis
  - → Granulomatous vasculitis ★ ★ TQ
  - ★ connective tissue dz
  - → Cause of death = decompensated right heart failure
- Group 2:
  - ★ Left Heart Disease
- Group 3:
  - ★ lung dz/Hypoxia → COPD
- Group 4:
  - ★ chronic thromboembolic

Plexiform lesion in pulmonary hypertension.



- Hydralazine - Drug induced lupus
  + isosorbide nitrate ⟶ AA. on ACEI + β blockers

- Aldosterone antagonists : attenuate fibrosis & remodeling
  ↑K+

- Ivabradine : EF<35% but HR>70 ⟶ causes Afib

- Milrinone : chronically on β-blocker

  know when to use milrinone vs dobutamine
  - both decompensated

- Sacubitril / Valsartan

- cyanide tox w/ Nitro

- diuretics failing - add thiazide