DVT-PE

- Mechanism (first three are Virchow's Triad pronounced "furko")
  - Endothelial Damage (?) 2/2 previous DVT, leg trauma, surgery, etc
  - Deep Venous Stasis (Mobilization, Venous Compression w/ (1) constant Thrombo Embolism Deterrent (TEDs) Hoses (same pressure across but overall increased), (2) constant Graduated Compressive Stockings (increased pressure distally pushing blood up), (3) intermittent Sequential Compressive Devices (SCDs) (increased pressure distally pushing blood up), NB do not use if active DVT or arterial insufficiency) 2/2 bed rest, immobility, recent surgery, CHF, venous obstruction, obesity, etc, low risk below knee vs high risk above knee, NB superficial femoral vein is actually a deep vein)
  - HyperCoagulation (Prophylactic AC) 2/2 refer
    ↓
  - Propagation (Therapeutic AC, if 2/2 catheter then remove)
    ↓
  - Embolization (IVC Filter)
  - NB other types of emboli (fat from long bone fractures, amniotic fluid from delivery, air from trauma/lines, septic from IE, Schistosomiasis, hair/cotton from IVDU, etc)
- S/S (NB 50% of pts w/ DVTs have no Sx, 50% of pts w/ DVT have asymptomatic PE, 50% of pts w/ PE have asymptomatic DVT)
  - Extremity: calf pain on dorsiflexion (Homan's Sign), palpable cord, phlebitis, edema, *phlegmasia cerulean dolens* (stagnant blood leading to ischemic)
  - Lung: tachypnea, SOB, DOE, cough, hemoptysis, rales
    CV: tachycardia, syncope, cp, loud P2, S3/4, cyanosis, hypotension, EKG (refer to EKG notes)
- Acute Complications
  - Lung: V/Q Mismatch, Pulmonary Ischemia/Infarction
  - Heart: Increased RV Demand w/ Resulting Cardiac Arrest
- Approach (PIOPED Study showed that clinical suspicion aka pre-test probability should be taken into account when interpreting diagnostic tests)
  - Approach to DVT
    - Low Pre-Test Probability: **D-Dimer** and if + confirm w/ below vs if – then stop
    - High Pre-Test Probability: **Compression Duplex US** and if + then Tx vs if – consider repeating in 1wk, **Venography**, or consider difficult to assess DVTs like proximal to inguinal ligament therefore consider **MRI** or in calf therefore consider repeating above studies b/c if it propagates it will usually w/in 1wk
    - NB there is difficulty distinguishing b/t residua from previous DVT w/ scarring and thrombus organization and a true recurrent DVT on US therefore use **Impedance Plethysmography**
  - Approach to PE
    - Low Pre-Test Probability then check **D-Dimer** (covalently bound D regions of two fibrin molecules and are formed as a result of degradation of cross-linked fibrin and therefore reflect rate of fibrinolytic activity on pre-existing thrombi but NOT rate of thrombus formation itself) and if + confirm w/ below vs if – then stop
    - High Pre-Test Probability then check either **Helical CT w/ Contrast** or **V/Q Scintiphotography** (normal = no PE, normal ventilation w/ perfusion defect = PE, ventilation defect w/ matching perfusion defects = indeterminate, ventilation defect that doesn't match perfusion defect = ?) and if either - but high suspicion and pt is sick then **Angiography** (gold standard, catches small PEs missed on HCT, invasive, uncomfortable) or if pt is not sick then pursue evaluation of DVT above
    - NB CXR: 12% nl but in 88% there is atelectasis, effusions, elevated hemidiaphragm, Hampton Hump (wedge shaped density abutting pleura), Westermark's Sign (avascularity distal to PE), Palla's Sign (enlarged R descending pulmonary artery)
  - Risk Stratification: TTE (RV dysfxn), cardiac biomarkers (troponin, BNP), clinical (hypoxemia, tachycardia/tachypnea, hypotension)
- Tx
  - DVT / Hemodynamically Stable PE
    - Oxygen
    - Heparin, Enoxaparin/Tinzaparin/Dalteparin, Fondaparinux, Argatroban/Lepirudin (all similar in efficacy and safety but Lovenox easier to give)
      - Heparin Products and when therapeutic begin 5d bridge to Coumadin w/ goal INR 2-3, if modifiable RF/idiopathic/recurrent cause or cancer or non-modifiable RF then Tx 3-6mo/6-12mo/12mo-lifelong
    - Greenfield IVC if AC contraindication and pt has DVT or pt has h/o PE and is at high r/o future DVT-PE
  - Hemodynamically Unstable PE
    - AC above but some say even higher loading dose
    - many pts who die from PE do so up to 2wks after presentation suggesting that recurrent PE in the presence of already hemodynamic instability is the cause hence the use of IVC filters in unstable pts
    - Catheter Directed Thrombolysis vs Angiojet Thrombo/Embolectomy if severe
    - although right heart strain is linked with worse outcome there is no data to determine how echo should be used
- Chronic Complications
  - **Death**

- **Recurrent VTE** (1%/yr after 1st VTE to 5%/yr after recurrent VTE, consider rechecking US/D-D after 3mo of Tx)
- **Post Thrombotic Syndrome** (pain, swelling, venous ulceration)
- **Pulmonary HTN** (chronic emboli is smaller vessels unlike in CTEPH which involves one large vessel)
- **Chronic Thromboembolic Pulmonary Hypertension aka CTEPH** (after a pt has an acute PE, perfusion returns to normal but in 5% of pts (only 1/2 of CTEPH pts have a h/o of an acute PE!) the thromboembolic material organizes into a scar causing chronic elevation in pulmonary vascular resistance and eventually cor pulmonale, some recommend routine post-PE Tx V/Q scans and TTE to screen, Tx: surgical thromboendarterectomy after mapping w/ angiography)

Pulmonary Arterial Hypertension (PAH)

- Definition
  - Mean Pulmonary Arterial Systolic Pressure > 25/30 mm of Hg at rest / during exercise (normal: 15 mm of Hg)
- Types (Venice Classification)
  - Primary (vasoconstriction and cellular proliferation of pulmonary arteries (NB unlike CTEPH which involves one large vessel PAH involves multiple smaller vessels))
    - Familial (AD mutation of bone morphogenic protein receptor 2 aka BMPR2)
    - Idiopathic (middle aged female)
    - Other (CVD esp scleroderma, Portal HTN, HIV, Flenfluramine, Pulmonary Veno-Occlusive Disease, Pulmonary Capillary Hemangiomatosis)
  - Chronic Emboli (chronic PEs from DVT, tumor, foreign material, parasites)
  - Pulmonary Disease associated w/ Hypoxemia (COPD, ILD, Sleep Disordered Breathing, Chronic High Altitude)
  - Left Heart aka Venous Disease (left heart disease)
  - Compression of Vessels (adenopathy, tumor, fibrosing mediastinitis)
- S/S
  - Cor Pulmonale (loud P2, split S2, TR, elevated JVD, heave) w/ DOE, syncope, fatigue, LE edema, ascites, etc
  - Hoarseness 2/2 compression of recurrent laryngeal nerve by enlarging pulmonary artery
  - CXR: CM w/ prominent pulmonary artery, RAE, RVH
  - PFTs: restrictive disease
- Dx
  - TTE: 90% sensitive at estimating mean PASP aka RVSP by Doppler interrogation of tricuspid valve regurgitant jet (initial test) NB also good at assessing RV overload/dysfxn and whether cause is 2/2 L heart disease
  - RHC: confirm mean PASP aka RVSP from TTE and if high then measure mean RAP to gauge severity of condition and predict future course (next test after TTE)
    - During RHC check response of CCB by performing an Acute Vasoreactivity Test (give a short acting vasodilator usually NO, adenosine, prostacyclin) as only 10% respond (decline in PASP by >10mm of Hg and concluding PAP <40mm of Hg with stable or increased CO) but if so then give chronic dihydropyridine CCBs (confirm effect and watch for SEs during RHC but remember that only 50% will be long-term responders) b/c substantially better prognosis but if non-responder then don't give CCB b/c of the detrimental effects of negative inotropy and hypotension and thus try unique drugs below (similar to CCBs confirm effect and watch for SEs during RHC)
  - Other: V/Q Scan, Pulmonary Angiography, etc
- Prognosis
  - Median survival of 2.8yrs after Dx but medicines below are changing that
  - BNP is linked w/ mortality
- Tx
  - NYHA I
    - Treat underlying cause
    - Oxygen to prevent hypoxemic induced vasoconstriction in pts w/ SaO2 <92%
    - **Chronic AC** b/c in situ thrombosis can occur, INR 1.5-2.5
    - Vaccination to avoid infections
    - Avoid valsalva, high altitudes, smoking, pregnancy, sympathomimetics, etc
  - NYHA II
    - " "
    - Acute Vasoreactivity Test
      - **Phosphodiesterase Inhibitors** (oral sildenafil) which vasodilates, etc, SEs: headache, vision changes, sinus congestion, hypotension, drug interactions, etc
  - NYHA III
    - " "
    - Acute Vasoreactivity Test
      - **Endothelin-1 Receptor Antagonists** (oral bosentan) which alters vascular remodeling process, etc, SEs: hepatoxicity, drug interactions, anemia, edema, etc
  - NYHA IV
    - " "
    - Acute Vasoreactivity Test
      - **Prostacyclin Analog** (subcutaneous trepostinil, intravenous epoprostenol, inhaled iloprost, oral beraprost) which vasodilates, alters vascular remodeling process, improves right ventricular

contractility, etc, SEs: jaw/leg pain, N/V/D/cramping, flushing, headache, catheter related problems b/c has to be given IV

- Other Meds (controversial)
  - Diuretics if RV overload, start at low dose and slowly to prevent hypotension
  - Digoxin/Dobutamine/Milrinone is controversial
  - Inhaled NO
- Surgery
  - Heart-Lung Transplant but sometimes heart recovers after just lung transplant
  - Palliative Balloon Atrial Septostomy creating a R to L shunt which increases CO but pt must be on oxygen