NUCLEAR CARDIOLOGY

Section Review

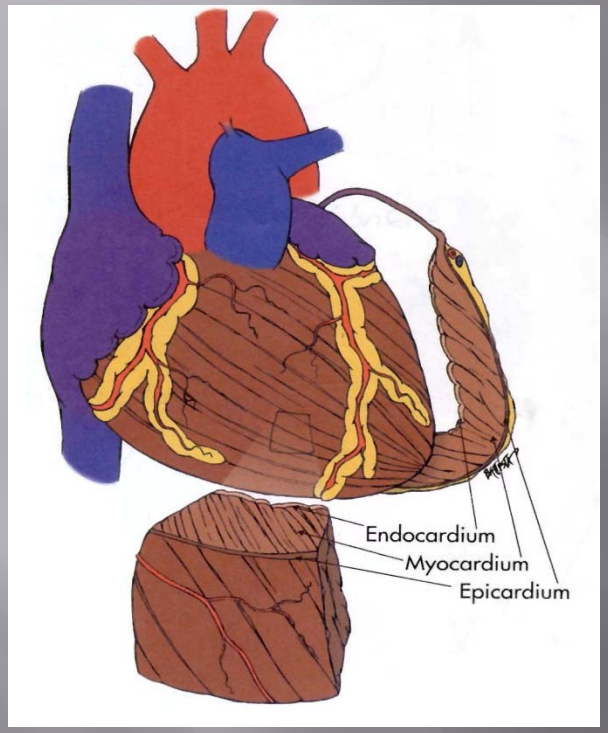
Objectives

- Clinical Problem
- Anatomy
- Physiology
- Radiopharmaceuticals
- Myocardial Necrosis Imaging
- Ventricular Function imaging
- Myocardial Perfusion and Viability

Clinical Problem

- 62 million people are diagnosed with some form of heart disease.
- 50 million suffer from hypertension.
- 12 million suffer from CAD.
- CAD is number one killer in U.S.
- As population ages, heart disease is becoming a prevalent problem.
- CAD causes ischemia which is a reversible condition.
- When left untreated, it can be deadly.
- Ischemia and consequent MI result from decades of plaque build up and can be controlled if detected early on.

Anatomy



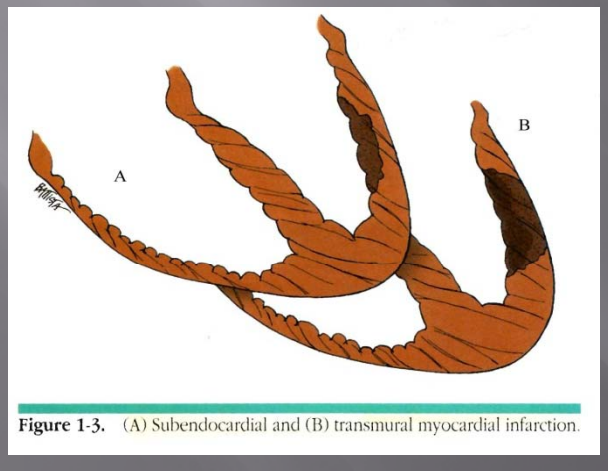
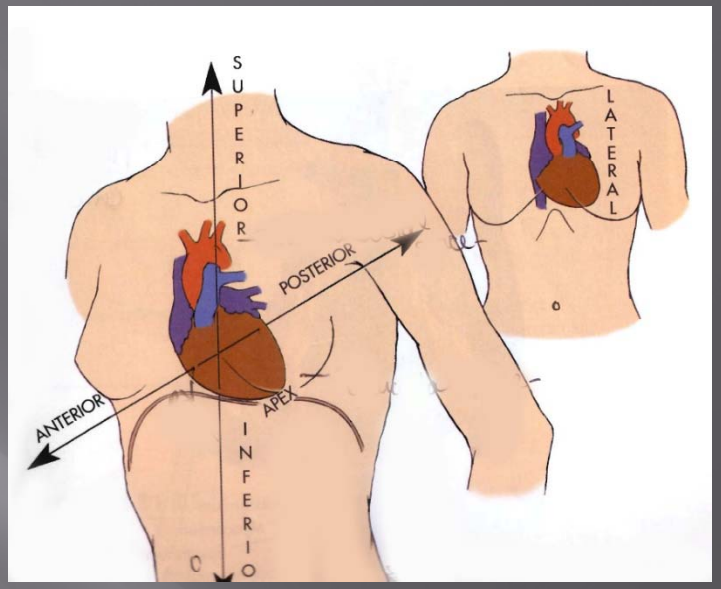
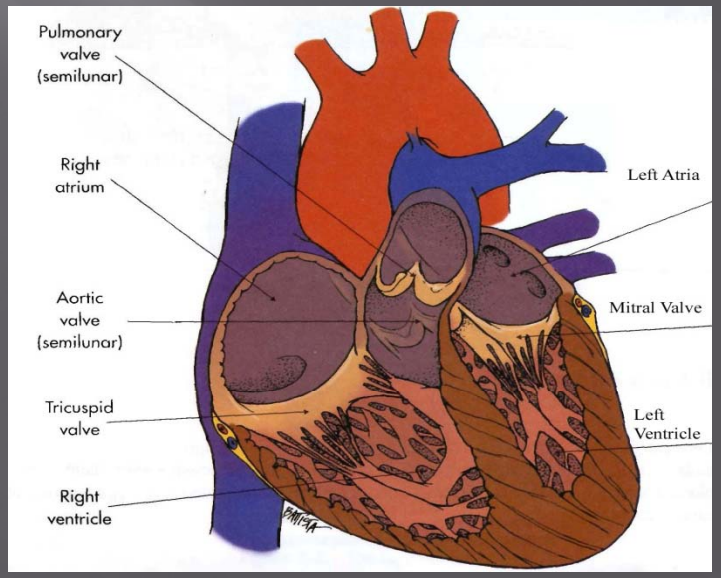
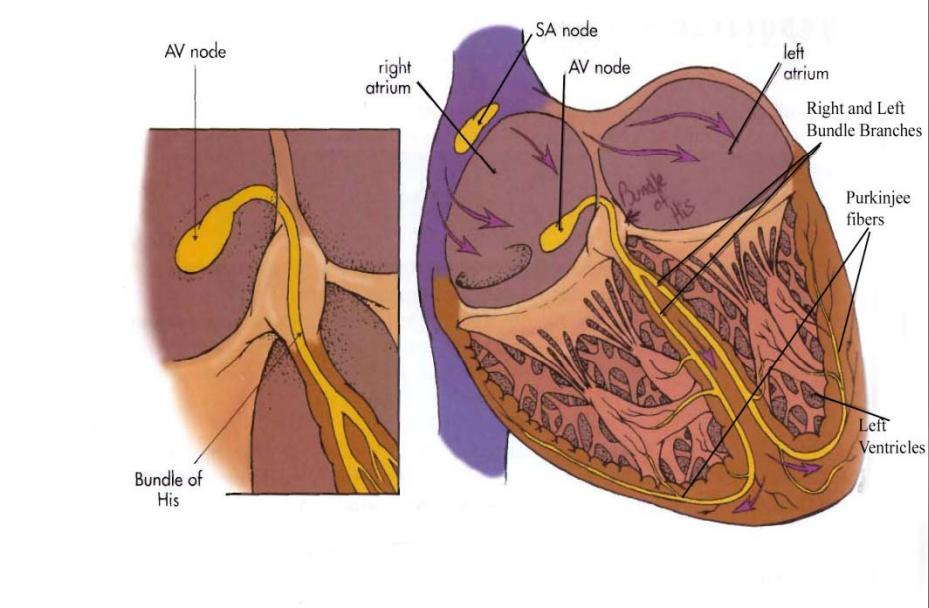


Figure 1-3. (A) Subendocardial and (B) transmural myocardial infarction.





Physiology



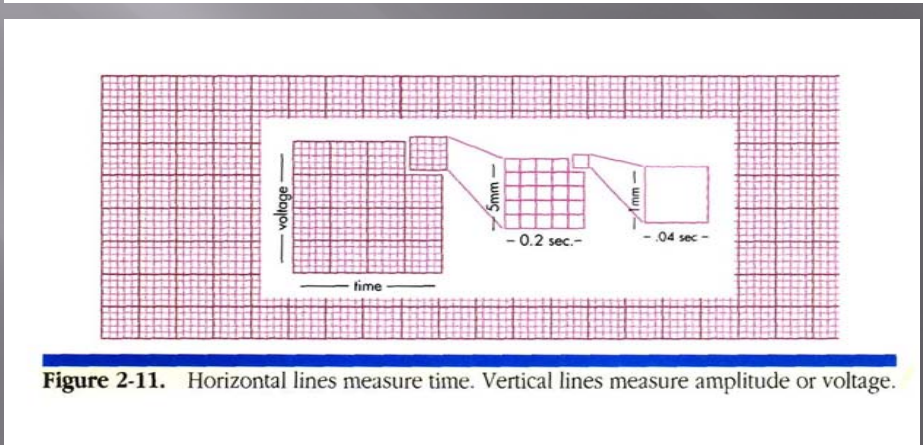


Figure 2-11. Horizontal lines measure time. Vertical lines measure amplitude or voltage.

Common Conduction Abnormalities:

1. Premature Systole: PAC or PVC. If the extrasystoles occur every other beat its called: bigeminy.
2. Ventricular Tachycardia: Originates in the focus of the ventricle. If left untreated may lead to ventricular fibrillation and eventually death.
3. Atrial Fibrillation: Totally disorganized firing at multiple sites in the atria, causes rapid irregular ventricular rate.
4. Left Bundle Branch Block: Slower depolarization of LV than RV
5. Right Bundle Branch Block: Slower depolarization of RV than LV.

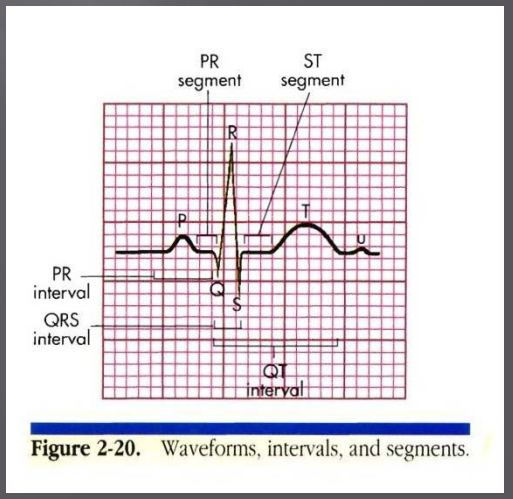


Figure 2-20. Waveforms, intervals, and segments.

Physiology

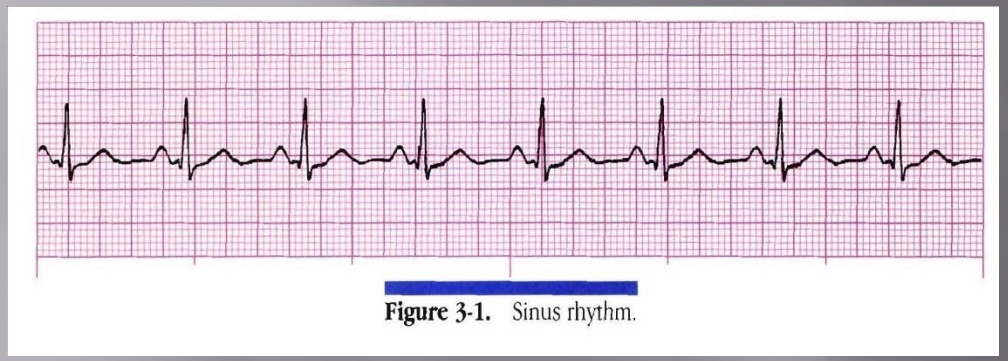


Figure 3-1. Sinus rhythm.

Normal

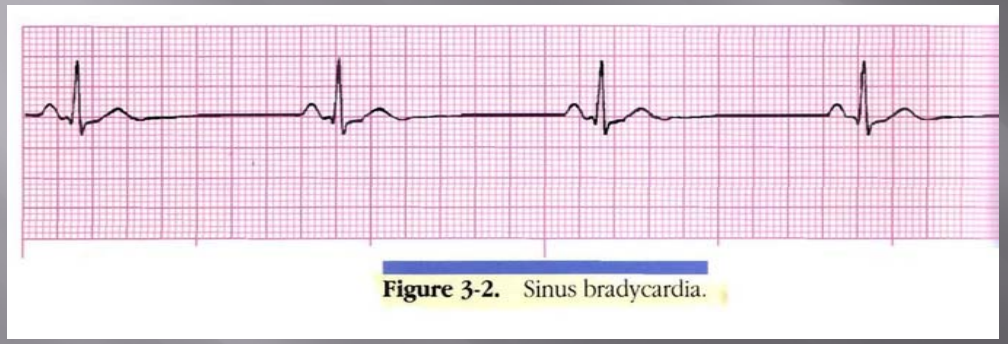


Figure 3-2. Sinus bradycardia.

Slow

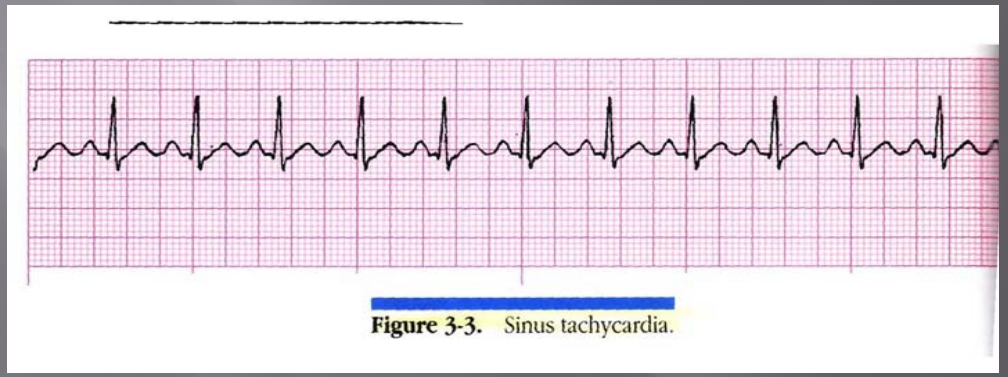


Figure 3-3. Sinus tachycardia.

Fast

Physiology

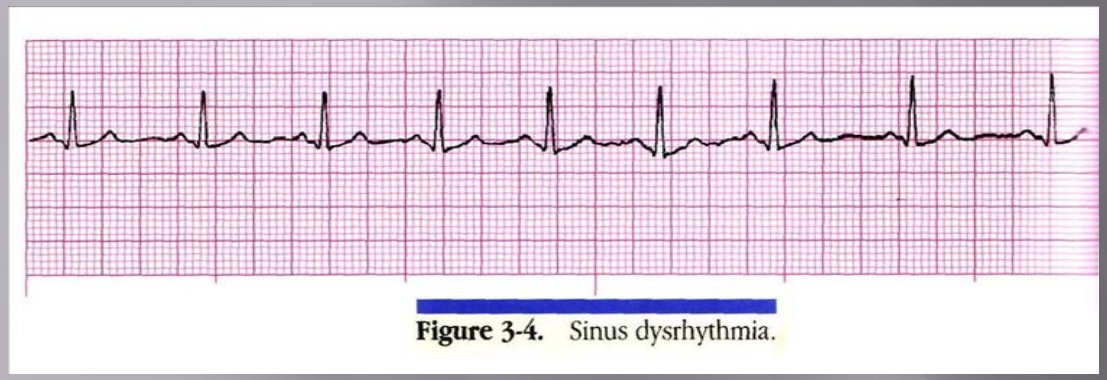


Figure 3-4. Sinus dysrhythmia.

Arrhythmia

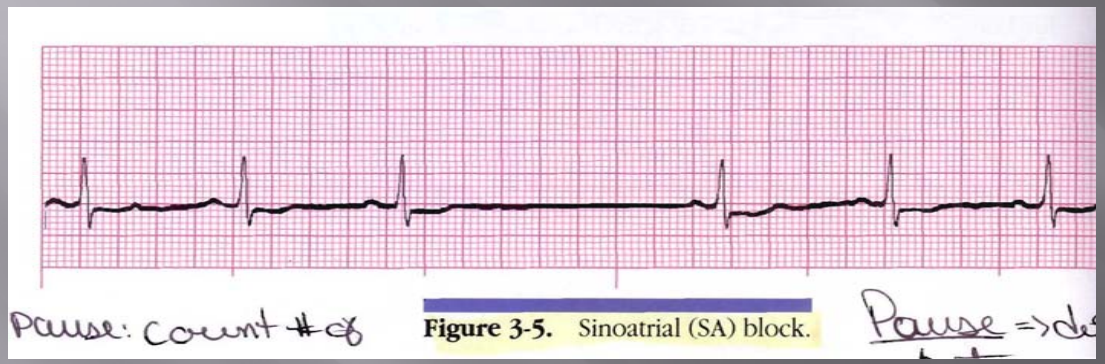


Figure 3-5. Sinoatrial (SA) block.

Pause

Figure 3-6. Sinus arrest.

Arrest

Radiopharmaceuticals

- Myocardial Necrosis
  - Tc99m PYP
  - In111 Antimyosin
- Ventricular Function
  - Tc99m RBC
- Myocardial Perfusion
  - Tl201 Chloride (perfusion and viability)
  - Tc99m Sestamibi (perfusion only)
  - Tc99m Myoview (perfusion only)
  - Tc99m Teboroxime (not available)

Necrosis Imaging

- Oxygen deprivation of 15 min leads to cell (myocyte death).
- Cell death leads to loss of tissue integrity. Molecules enter and exit freely.
  - CPK, LDH, Troponin, Myoglobin: released into blood stream and often detected in ER. Elevated levels may not always mean MI (other sources may cause interference).
- White Bloods cells migrate to clean up debris, Fibroblasts migrate to repair holes with fibrous tissue.
- Tc99m PYP uptake is associated with fibrous tissue formation. (20mCi min 4 hr delay, within 12 hr – 10 days post MI). Use grading scale to quantify
- In111 Antimyosin uptake associated with the inflammation process (WBC migration). Useful for transplant rejections, and MI. (1.8mCi, delayed imaging possible, quantification through ratio.

Ventricular Function

- Indications: wall motion abnormalities, EF evaluation, chemo/cardiotoxicity monitoring and follow-ups.
- EF= (ED counts – ES counts)/ED counts.
- In Vivo: 60-90% efficiency. Affected by hematocrit, current medications, etc.
- In Vitro: 95% efficiency. Simple, easy to use.
- Modified In Vivo: 90-95% efficiency. Maybe used if In Vitro kit not available.
- MUGA: multigated acquision. A cardiac cycle is broken down into frames (8 or 16). Frames of the consecutive cardiac cycles are superimposed over the previous cardiac cycle. This produces a beat-rich and count-rich single cycle cine image.
- Planar: ANT, LAO45, LLAT or LAO70.
- SPECT: provides better resolution, visualization of ALL walls, ability to separate overlying structures, obtain more accurate EF.
- Data Analysis: Visually estimated EF. Then draw ROI to fit the ED and ES. BKG ROI placement is crucial. Normal: 50 – 75%

Myocardial Perfusion

- Concentration of radiopharmaceuticals in myocardium is directly related to myocardial perfusion at stress. Greater perfusion = greater concentration of isotope, lesser perfusion = lesser concentration of isotope.
- Radiopharmaceuticals:
  - Tl201 – K analog, constantly being pumped in and out of myocardium, redistribution, low energy, longer t 1/5. 3.5% of Tl201 is localized in myocardium through active transport. (mycardial blood flow = 4%, Tl201 has 88% extraction rate). Only 10% of Tl201 is excreted out of the body thus long biological t ½.
  - Tc99m Sestamibi and Myoview – no redistribution, optimal energy, optimal t 1/2. Passive diffusion into mitochondria. 60% of Cardiolite / 50% of Myoview are extracted from the blood into the myocardium. Larger doses are injected, while more of the isotope is excreted out of the body. Combined with shorter t ½ patient will receive less radiation burden.
- Protocols:
  - Tl201: single day, stress first, imaging begins within 10 minutes, booster injection, rest 4 hours later.
  - Sestamibi/Myoview single day (stress or rest first?). First dose 7-10mCi, second dose 21-30mCi. Second dose is 3 X the first dose. Liver bowel clearance is VERY IMPORTANT, wait NO LESS THAN 45 minutes post injection. Treadmill = less liver uptake, Pharmacological stress = higher liver uptake. WHY?
  - Sestamibi/Myoview two-day: 30 mCi each day. Obese patients best candidates. Best way to deal with soft tissue attenuation. Ideal protocol for physician scheduling.
  - Dual Isotope: Tl201 rest, Tc99m MIBI/Myoview stress. Very efficient protocol. However, some argue apples vs. oranges: more attenuation with Tl201 than MIBI/Myoview, and different methods of localization.

Attenuation Problems

- Arms down: Lateral wall attenuation. Extend imaging time, keep the same position of the arms during rest and stress imaging.
- Breast attenuation: Anterior/Anteroapical defect. Strap around chest may help.
- Hot Liver/ Bowel: Inferior wall affected. Wait more time, large amount of water will clear bowel.
- Attenuation correction with Gd/CT may help. Often focus of great debate among professionals.
- Review of wall motion: May reveal if the defect is real or not. Helps differentiate attenuation vs. real defect.
- ALWAYS REVIEW RAW DATA!!!
- Triple vessel disease: balanced disease in all three vessels will result in uniform distribution of the isotope in myocardium on stress. Stress EKG, wall motion as well as ventricular size should all be examined carefully.
  - Note: Ventricular size is relevant only if the patient exercised. If pharmacological stress, then its meaningless.

Stress Protocol

- Exercise:
  - Bruce
  - Modified Bruce
    - Prep: NPO, Discontinue: caffeine, chocolate, antiarrhythmics, beta-blockers, calcium channel blockers, diuretics, nitroglycerin.
    - Contraindications: marked arrhythmia, tachy, PVC's, A-fib, drop in BP, Severe CP, Severe SOB, Severe fatigue, or leg pain.
    - (220-age) x .85 = targeted heart rate. Achieving 100% or max HR => more accurate results. Exercise for at least 2 min post injection of isotope.
    - Exercise => myocardium requires more oxygen => normal vessels open-up to accommodate while diseased don't.
- Pharmacologic
  - Adenosine: naturally occurring compound. Infused for 4 or 6 minutes. Dilates normal coronaries at least 3 to 4 times their normal diameter. Isotope is injected during peak of adenosine effect. Adenosine is infused for at least 2 minutes post isotope injection. Biological t ½ is only 13 seconds. Antidote not necessary.
    - Prep: NPO, No caffeine, chocolate, antiarrhythmics, beta-blockers, calcium channel blockers, diuretics, nitroglycerin. Caffeine and chocolate will work as natural antidotes to adenosine.
    - Contraindications: COPD, Asthma, Emphysema, wheezing.
  - Persantine: Increases levels of secreted adenosine. Longer lasting, biological t ½ is 12 minutes, side-effects are more pronounced, often requires aminophylline as antidote. Peaks after the completion of the infusion, isotope injected after the infusion of persantine.
    - Prep: NPO, No caffeine, chocolate, antiarrhythmics, beta-blockers, calcium channel blockers, diuretics, nitroglycerin. Caffeine and chocolate will work as natural antidotes to adenosine.
    - Contraindications: COPD, Asthma, Emphysema, wheezing.
  - Dobutamine: Acts to increase the HR and consequently causes the coronaries to dilate. Infused in stages, from 10 ug/kg/min, and increasing by 10 ug every 3 minutes. Isotope injected when 85% max HR is reached. Atropine may be given to increase HR at the last stage of dobutamine infusion. BP will increase, HR will increase.
    - Prep: NPO, stop beta blockers.
    - Contraindications: Arrhythmias, severe SOB, CP, palpitations.

Mycardial Viability

Irreversible tissue: MI

Reversible tissue: Ischemia, Stunning, Hibernating.

Hibernation: chronic reduction in coronary blood flow leading to decrease in contractile function that can be reversed by improving coronary flow. Thallium will show hibernation as delayed filling in.

Stunning: altered metabolic and contractile function that follows an ischemic episode. The only true way to diagnose stunning is to re-image the patient several months after the original scan to visualize stunning reversibility.

Patient selection:

Recent MI.

Patients who are unstable to be stressed.

Low EF

Recent stress test (positive).