Cardiovascular System

Part 3

Heart Disease

- Coronary artery disease (CAD)
  - Atherosclerosis
    - Coronary arteries develop plaque
      - Made of cholesterol, fat [mostly unsaturated], calcium, and other substances
    - Arteries narrow over time

Heart disease

- Angina pectoris
  - Causes
    - Atherosclerosis
    - Stress induced spasm of coronary arteries
    - Increased physical activity
  - Treatment
    - NBC

Treatment of Angina Pectoris

- Nitrovasodilators
- Beta Blocker
- Calcium Channel Blocker
- Vascular Bed
  - Preload
- Coronary Dilation
- Arterial Bed
  - Afterload
Heart Disease

- **Myocardial infarction**
  - Heart attack
  - Causes
    - Prolonged blockage of coronary arteries
      - Thrombosis – a clot
      - Embolism – a clot that breaks free from a thrombus and causes a problem somewhere else
    - Atherosclerosis

Arrhythmias

- **Collateral circulation may prevent infarction**

Arrhythmias

- **Damaged conduction system**
- May be caused by heart attack, other causes
  - Electrolyte imbalances, valve disorders, hypertension, cardiomyopathy
- Classification by rate, mechanism, location
  - Atrial flutter
  - Atrial fibrillation
  - Ventricular fibrillation
  - AV node block

Arrhythmias

- **Arrhythmias occur occasionally in almost all healthy individuals**
  - Examples: premature ventricular contractions, respiratory sinus arrhythmia
Arrhythmias

- Atrial flutter
  - Atria contract more often than ventricles (160-220/min)
  - Prevents normal refilling of ventricles
  - "Sawtooth" pattern – T-P interval disappears

Arrhythmias

- Atrial fibrillation
  - Activation of atria fully irregular and chaotic
  - Ventricular rate becomes rapid and irregular

Arrhythmias

- Ventricular fibrillation
  - Completely uncoordinated, chaotic ventricular contraction
  - Fatal within minutes if not immediately rectified

Abnormal EKG’s

- Enlarged P wave
  - Enlarged atrium
  - Mitral stenosis
Abnormal EKGs

- 1st degree nodal block
  - Transmission from SA to AV node delayed
- 2nd degree nodal block
  - Not all SA impulses reach ventricles
- 3rd degree nodal block
  - Complete block – no impulse is conducted to the ventricles from the SA node
  - Ventricular contraction uncoordinated
  - Caused by inferior myocardial infarction, excess vagal tone, drugs (Ca\(^{2+}\) channel blockers, beta-blockers, digoxin)

Abnormal EKGs

- 1st degree
  - Delay in transmission from SA to AV node
  - Increased P-R interval

Abnormal EKGs

- 2nd degree
  - Not all SA impulses make it to the AV node
  - "Dropped" ventricular contractions

Abnormal EKGs

- 3rd degree
  - P waves and QRS complexes seen, but at 2 different rates

Abnormal EKGs

- 3rd degree
  - P waves and QRS complexes seen, but at 2 different rates
Abnormal EKGs

- Bundle branch block
  - Defect in transmission in either bundle branch to one side of heart
  - Activation of ventricle must await initiation by opposite ventricle
  - Result: ventricles do not contract together

Abnormal EKGs

- Enlarged R
  - Ventricular hypertrophy
  - Due to ventricular overload
    - Caused by valve disorders, pulmonary (right) or systemic (left) hypertension, obstructive hypertrophic cardiomyopathy
    - Increases electrical forces directed to the affected ventricle

Abnormal EKGs

- Q and ST deviations
  - Problems with ventricular depolarization and repolarization
  - Seen in MI
Abnormal EKGs

- T waves
  - High = hyperkalemia
  - Low = ischemia, hypokalemia
  - Inverted = normal variant in children, may persist; also caused by ischemia, MI

Risk Factors for Heart Disease

- High cholesterol
- High blood pressure
- Smoking
- Obesity
- Inactivity
- Diabetes mellitus
- Personalities
- Family history

Circulatory Shock

- Decreased perfusion to body tissues
- Mechanisms
  - Cardiogenic shock
  - Hypovolemic shock
  - Vasodilatory shock

Circulatory Shock

- Cardiogenic shock
  - Cardiac output becomes insufficient or non-existent (MI)

Circulatory Shock

- Hypovolemic shock
  - Blood volume loss (hemorrhage or bleeding ulcer)

Circulatory Shock

- Vasodilatory shock (AKA distributive shock)
  - Spinal cord injury, septic shock, anaphylaxis
**Decline in tissue perfusion**

- Tissue hypoxia
- Cells release circulatory mediators

**Compensation**

- Early compensatory mechanisms
  - Vasoconstriction in periphery
  - Vasodilation in coronary and pulmonary circuits
  - Epinephrine increases HR, vasoconstriction
  - Water retention to elevate BP
    - Increased aldosterone
    - ADH

**Circulatory shock**

- Hypovolemic shock
  - Cardiac output may return to normal
- Vasodilatory and cardiogenic shock
  - High mortality rates

**Congestive Heart Failure (CHF)**

- Pumping efficiency (cardiac output) doesn’t meet tissue needs
- Common causes
  - Coronary atherosclerosis
  - Persistent high blood pressure
  - Multiple myocardial infarcts
  - Dilated cardiomyopathy (DCM)
    - Left ventricle enlarged and weakened

**Fick’s Principle**

- Oxygen consumption is a function of the rate of blood flow
- Most accurate measurement of CO (Q)
  - But... Invasive, requires time for the sample analysis
  - Accurate oxygen consumption samples are difficult to acquire
- Calculate the amount of oxygen consumed over a given period of time
  - Measurement of O₂ concentration of venous and arterial blood
  - Lab 10

\[ Q = \frac{\text{VO}_2}{\text{C} - \text{C}_v} \times 100 \]
Congestive heart failure

- Symptoms
  - Cough
  - Swelling
  - Shortness of breath
  - Weight gain
  - Irregular, rapid pulse
  - Fatigue, weakness, fainting
  - Nausea/vomiting
  - Decreased urine output
  - Difficulty sleeping

Left sided CHF

- Blood pools (backs up) where?

Right sided CHF

- Blood pools (backs up) where?

Cor pulmonale

- Caused by elevated blood pressure in pulmonary circuit
  - Pulmonary hypertension
- Increased workload for which part of the heart?
- What do you think it could be caused by?
Cardiac Tamponade

- Heart is compressed by fluid in pericardium
- Causes
  - Pericarditis
  - Myocardial rupture
  - Trauma
- Emergency!
  - Can rapidly affect cardiac output

Pulmonary hypertension

- Increased blood pressure in pulmonary circuit
- Causes
  - Low O₂ conditions
  - Birth defects
  - CHF
  - Valve disease
  - Drugs (e.g., cocaine)
  - Pulmonary emboli
  - COPD
  - Idiopathic (no recognized cause)

Broken heart syndrome

- AKA Takotsubo cardiomyopathy
- Sudden weakening of the myocardium
- Stress induced, temporary condition
  - Women > men
  - Stress hormone surge
  - Reverses in 1 week
  - Recently discovered: can also happen in response to intense positive emotions

Heart surgery techniques

- Strategies
  - Hypothermia
  - Extracorporeal circulation
  - Cardiac stabilizers
    - Octopus 2 (0:37 – 2:15)

Heart surgery techniques

- Aortic aneurysm
- Surgical options:
  - Stent
  - Synthetic graft
  - Graft with stent
Heart surgery techniques

• Stent
  — Note: your study guide says “graft” – they mean stent

Heart surgery techniques

• Graft with stent
  — Currently most common for aortic aneurysm

Heart surgery techniques

• Types of repair
  3. Coronary bypass
  4. Drug coated stent

Heart surgery techniques

• Coronary bypass
  — Bypass the clogged artery with a synthetic graft or actual veins
    • Internal mammary artery
    • Saphenous vein

Heart surgery techniques

Single  Double  Triple  Quadruple

Coronary Artery Bypass Graft (CABG)
Heart surgery techniques

- Types of repair
  5. Endarterectomy
  6. Dacron
  7. Artificial valves
  8. Artificial heart

**Endarterectomy**

**Dacron**

- Polyester textile fiber
- May be used as a graft, or to seal leaks

**Artificial heart and valves**

**Bonus: VAD**

- Ventricular assist device

Heart surgery techniques

- Types of repair
  9. Percutaneous transluminal coronary angioplasty
  10. Pacemaker
  11. Ablation
Percutaneous transluminal coronary angioplasty

Pacemaker

Ablation

Patent Foramen Ovale (ASD)
- Normal fetal structure
- Allows blood to bypass fetal lungs
- Sometimes fails to close

Patent Foramen Ovale (ASD)
- Used to be repaired with open heart surgery
- Now repaired in an hour with a septal occluder device

Tests for heart disease
1. Coronary catheterization and angiography
2. Chest radiographs
3. EKG
4. Holter monitor
5. Echocardiography
6. Stress tests
7. MRI and CT
8. Cardiac markers in blood