The Cardiovascular System
Blood Vessels

- **Arteries**
  - Carry blood away from the heart
    - Thicker than veins
  - Larger arteries
    - Aorta
      - Elastic
      - Expanding with the internal pressure of systole and recoil during diastole
Blood Vessels

- Arteries
  - Smaller muscular arteries
    - Contract or dilate to accommodate blood flow
  - Coronary arteries
    - From the aorta
      - Supply the heart with blood
Blood Vessels

- Veins
  - Thin
  - Not elastic or able to dilate or contract
  - Have valves to prevent backflow

- Capillaries
  - Thin
  - One cell layer vessels where oxygen, nutrients and waste products are exchanged with the cells
Lymphatic Vessels

- Allow flow of lymph
  - Similar to blood without RBCs or clotting factor
  - Formed from extracellular fluids
  - Flows from one peripheral tissues to the heart

- Lymph Nodes
  - Filter bacteria and toxic substances from lymph
    - Contain WBCs
Heart

- Surrounded by a pericardial membrane which protects it from trauma & infection
  - 2 layers to the membrane
    - Fibrous pericardium = outer layer
    - Parietal pericardium
    - Visceral pericardium or epicardium = smooth epithelium covering external surface of the heart
Heart & Pericardial Membrane

- 2 of the layers are separated by pericardial fluid
  - Prevents friction between them when heart beats
  - Between parietal and visceral pericardia
Heart Chambers

- 2 upper chambers: atria
  - thin walled
  - Separated by thin septum
  - Receives blood

- 2 lower chambers: ventricles
  - thick and muscular
  - Pumps out blood
Heart

- **Right Side**
  - Pumps blood to the lungs to be oxygenated

- **Left Side**
  - Pumps oxygenated blood to the head and rest of the body
Layers of the Heart

- Pericardium
  - Thin outer layer
- Myocardium
  - Thick middle layer formed by striated muscle
- Endocardium
  - Smooth inner layer
4 Heart Valves

- Atrioventricular valves (2)
  - Separate atria and ventricle
    - Tricuspid (RA and RV)
    - Mitral (LA and LV)

- Semilunar valves (2)
  - Regulate outflow of each ventricle
    - Pulmonary (RV and pulmonary artery)
    - Atrial (LV and aorta)
Circulation of the Heart

- Deoxygenated blood from vena cava flows into R atrium
- Tricuspid valve allows blood to flow into R ventricle
- Pulmonary valve opens, blood leaves R ventricle and goes to lungs via pulmonary artery
- Blood is oxygenated
Circulation of the Heart

- Oxygenated blood from lungs returns to heart via pulmonary veins and enters L atrium
- Mitral valve allows blood to flow into L ventricle
- Blood exits L ventricle through aortic valve
Heart Rate

In adults:

- 60 – 100 bpm normal
- >100 tachycardia
- <60 bradycardia
Symptoms of Cardiovascular Disease

- Chest/neck/arm pain
- Cyanosis
- Dyspnea
- Edema
- Fatigue
- Syncope
- Palpitations
Diseases of the CV System

- Congenital Heart Disease
  - May not be apparent until later in life
  - 50 such conditions have been identified
    - May be simple isolated defects or complex malformation syndromes
Diseases of the CV System

- Congenital Heart Disease Etiology
  - Most are idiopathic
  - Others
    - Rubella (virus)
    - Alcohol - directly affecting the fetal heart
    - Chromosomal abnormalities
Congenital Diseases of the CV System

- Septal Defects
  - Most common form of Congenital Heart Disease
    - 30-40% of clinically recognized cases
  - Septum separates R and L side of heart
Congenital Diseases of the CV System

- Congenital Heart Disease
  - Atrial Septal Defects
    - Until birth, venous blood enters the L atrium from the R atrium via the foramen ovale.
    - Failure of this opening to close or incomplete formation of the septum results in atrial septal defects
    - Blood flows from high pressure in L atrium to R atrium
Congenital Diseases of the CV System

- Ventricular Septal Defects
  - The most common congenital heart defect
  - More serious than interatrial defects
    - L>R shunt
    - R ventricle becomes overburdened and hypertrophies
Congenital Diseases of the CV System

- Ventricular Septal Defect
  - Increased pulmonary blood flow causes pulmonary HTN & Narrowing of the pulmonary artery
  - Increased pressure in RV causes R>L shunt, reducing the O2 content of the systemic circulation causing cyanosis
Diseases of the CV System

- Septal Defects produce distinct murmurs and are easily detected by experiences pediatricians.
Congenital Heart Disease

- Tetralogy of Fallot
  - Complex defect of heart and vessels
  - Four typical lesions
    - Valvular stenosis of the pulmonary vessels
    - Ventricular septal defect of the upper part of the septum
    - Aorta is displaced receiving blood from both ventricles
    - R ventricular hypertrophy
Tetralogy of Fallot

- Babies born with this defect are cyanotic and most die before puberty if the condition is not surgically corrected.
Atherosclerosis

- Systemic disease affecting the arteries:
  - “hardening of the arteries”
  - Can affect any artery, but more prevalent in:
    - Heart
    - Brain
    - Aorta
    - Extremity vessels
Atherosclerosis Pathogenesis

- Initial arterial wall injury to endothelium
  - Metabolic derangement
  - Physical force
- Deposition of lipoproteins and platelets
- Growth factor from platelets stimulates proliferation of smooth muscle cells in arterial wall
Atherosclerosis Pathogenesis

- Altered environment and smooth muscle metabolism causes accumulation of cholesterol & other lipids in cytoplasm
- Collagen surrounds the soft lipid deposits and leads to hardening of the arteries (sclerosis)
- Complications: thrombosis, aneurysm
Atherosclerosis Risk Factors

- Non modifiable
  - Age
  - Gender
  - Family history
  - Ethnicity
  - Infections
Atherosclerosis Risk Factors

- Modifiable
  - HTN
  - Hyperlipidemia
  - Smoking
  - Stress
  - High cholesterol
  - Poor nutrition
  - Clotting factors
Atherosclerosis of the Aorta

- Common in men > 50
  - usually asymptomatic
  - Starts as plaques and fatty streaks
    - Lumen of aorta narrow
    - Atheromas and plaques calcify
      - Elasticity of the aorta decreases
    - Rigid aorta cannot adapt to pressure changes HTN
    - HTN causes aorta to dilate -> aneurysm
Aneurysms

- Abnormal dilation (stretching) of wall of artery, vein, or heart
- Often clinically silent, but may rupture or dissect
- Can be resected and repaired surgically using and artificial material
Peripheral Vascular Disease

- Involves the arteries that supply the extremities and major abdominal organs
- Common in:
  - the elderly
  - Diabetics
  - Hyperlipidemia
  - HTN
Peripheral Vascular Disease

- Atherosclerosis of the Renal Arteries
  - Decreasing kidney function
  - Leading to HTN
  - Reduced Na and urine secretion, worsens HTN
  - Further damaging the kidneys
  - Eventually leads to End Stage Renal Disease
    - ESRD
Peripheral Vascular Disease

- Atherosclerosis of the extremities
  - Affects the LEs more often than the UEs
    - Chronic ischemia
      - Decreased sensation
      - Slower healing
      - Sudden occlusion
        - Gangrene
Intermittent Claudication

- Disease in popliteal artery
- Severe pain in calf during walking, exercise, prolonged standing
- Rest alleviates the symptoms
- Pain due to insufficient blood supply to muscle
Coronary Artery Disease (Coronary Atherosclerosis)

- Main characteristic: ischemia
- Pathology: slowly progressive narrowing of coronary arteries or a sudden occlusion. Both leading to restricted blood flow to cardiac tissues
Coronary Artery Disease

- Non atherosclerotic causes:
  - Kawasaki disease
  - Metabolic syndromes
  - Trauma
  - Radiotherapy
  - Connective tissue diseases
Coronary Artery Disease

- Can present as:
  - Angina pectoris
  - Myocardial infarction (MI)
  - Congestive heart failure (CHF)
Angina Pectoris

- Imbalance between cardiac workload and O2 supply
- Chest pain (squeezing, pressure) which may radiate to other parts of body
- Acute attack treated with nitroglycerin (vasodilator)
- Treatment also focuses on underlying disorders
Myocardial Infarction

- Sudden occlusion of coronary artery
- Leads to irreversible cell death
  - Formation of fibrous scar
- Symptoms
  - Prolonged crushing chest pain (longer duration than angina)
  - SOB
  - Loss of consciousness
  - Sweating
  - Nausea
Myocardial Infarction

- Diagnosis:
  - Symptoms
  - EKG
  - Cardiac enzymes
    - Cardiac troponins (I and T)
    - Creatine kinase (CK)
  - CT, MRA, echocardiogram
Myocardial Infarction

- Treatment:
  - Medications
  - Angioplasty
  - Stents
  - CABG
Congestive Heart Failure CHF

- Heart is unable to pump sufficient blood for body’s needs
- Hypoxia of myocardium causes pump failure
- May occur on only 1 side of the heart
Congestive Heart Failure

- Causes:
  - MI
  - Valve incompetence
  - Prolonged HTN
  - Very high or very low HR
Congestive Heart Failure

- L sided heart failure
  - Prevents the heart from pumping enough blood to into circulation
  - Leads to pulmonary congestion and edema
    - Dypsnea
Congestive Heart Failure

- R sided heart failure
  - Prevents the heart from pumping adequate blood into lungs
  - Leads to peripheral edema and venous congestion in organs
Hypertension

- American Heart Association
  - Normal: less than 120/80
  - Prehypertension: 120-139/80-89
  - Stage 1 HTN: 140-159/90-99
  - Stage 2 HTN: 160 and above/100 and above
HTN

- Primary (essential) HTN
  - 90% of cases
  - No established etiology
  - Probably related to genetics and other risk factors
  - Treated with meds and/or lifestyle changes
HTN

- Secondary HTN
  - Results from identifiable cause
    - Pregnancy
    - Diseases
    - Medications
HTN Pathogenesis

- Blood pressure is regulated by:
  - Blood flow
    - Determined by cardiac output
  - Peripheral vascular resistance
    - Determined by diameter of vessels and viscosity of blood
    - Regulated at arterioles
Pathologic Consequences of HTN

- Vascular Pathology
  - Atherosclerosis is accelerated
  - Hyalinization and hyperplasia of the smooth muscle cells of the arterioles
  - Fibrosis of small arteries
  - Narrowing of arterioles and release of rennin promoting renal ischemia
    - Increased HTN
Pathologic Consequences of HTN

- Hypersensitive encephalopathy
  - Vascular changes in the brain that cause ischemia
  - Micro-infaracts
    - Minimal memory changes
  - Hypertensive stroke
    - Sudden rupture of brain arteries
Orthostatic Hypotension

- Decrease in BP upon standing from supine or sitting position
- Accompanied by dizziness, blurry or loss of vision, syncope, fainting
Infectious Heart Disease

- The heart is prone to blood borne infections
- Myocarditis
  - typically caused by viruses or parasites which must invade the myocardial cells to survive
    - The organisms kill the myocardial cells
      - Weakening the heart and contributes to heart failure
  - Symptoms are vague and diagnosis not made easily
Infectious Heart Disease

- **Endocarditis**
  - Bacterial infection of lining of heart or valves
  - Causes breakdown of connective tissue in valves
  - Valves become inflamed and stop performing normal functions
Cardiomyopathies

“a group of diseases affecting the myocardium that are incurable and eventually require transplantation”
Cardiomyopathies

- Causes:
  - MI
  - Alcoholism
  - Longer term, severe HTN
  - Infections
  - SLE
  - Celiac disease
  - End stage renal disease
Cardiomyopathies

- 3 forms
  - Dilated
  - Hypertrophic
  - Restrictive
Cardiomyopathies

 Symptoms:
- SOB
- Cough
- Palpitations
- Edema
- Angina
- Dizziness
- Low urine output
- Deconditioning
- Altered mental alertness
Cardiac Tumors

- Primary Tumors of the heart are extremely rare
Diseases of the CV System

- **Venous Diseases**
  - Veins have thinner non-muscular walls
    - Not affected by HTN or Atherosclerosis
  - Can accommodate increased amount of blood
    - Accounts for pooling of blood from CHF
  - Backpressure causes stagnation of blood
    - Valves become incompetent
  - Once veins dilate, remain that way
    - Varicose veins
  - Slow flow increases risk for clotting
Venous Diseases

- Thrombophlebitis
  - Occlusion of a vein in LEs
  - DVT can be life threatening

- Venous stasis ulcer
  - Inadequate blood flow and ischemia associated with chronic venous insufficiency
Lymphatic Disease

- Lymphedema
  - Accumulation of interstitial fluid resulting from obstruction of lymphatic vessels
  - Disorders of lymph nodes
    - Surgical removal for the treatment of CA
Cardiac Medications

- **Diuretics**
  - Increase excretion of Na and H2O
  - Control HTN and fluid retention
  - Lasix

- **Beta-blockers**
  - Relax vessels of the heart muscle
  - Reduce HR and BP
  - Atelond, propanolol, Iopressor
Cardiac Medications

- **ACE inhibitors**
  - Treat HTN and heart failure
  - Vasotec, capoten

- **Calcium channel blockers**
  - Lower BP and suppress some arrhythmias
  - Procardia, cardizem, norvasc

- **Nitrates**
  - Treat angina
  - Sublingual
  - Nitrostat