The Cardiovascular System

Blood Vessels
- Tubes which carry blood through the body
- Blood should flow in only ONE DIRECTION
- Three types:
  - Arteries
    - carry blood AWAY from the heart
    - thick, muscular walls
    - NO VALVES
    - Do NOT have to contain oxygenated blood
  - Veins
    - carry blood TOWARD the heart
    - thin walls (little muscle)
    - HAVE VALVES
    - May contain oxygenated blood
  - Capillaries
    - direct transfer between cells and blood
    - one-cell thickness between parallel capillaries

Veins vs. Arteries

Arteries
- Arteries are covered with a muscle layer
- Artery expands as the heart pushes blood
- Artery recoils when heart is relaxed
  - helps to keep blood moving
- These features are
  - measured as BLOOD PRESSURE
  - can be felt as a PULSE

Know/understand the names in the colored boxes
Atherosclerosis

1. How thrombosis begins
   Atheromatous plaque forms from a collection of fatty substances, waste products, calcium, and fibrin, a stringy substance that helps blood clot.

2. Clot formation
   The growing atheroma reduces blood flow and oxygen delivery to the tissue. The plaque ruptures, causing the sudden formation of a clot.
Veins

- Little muscle
- Blood easily slowed/stopped

Deep Vein Thrombosis (DVT)

- Thrombus (blood clot) can form in any blood vessel
  - Common in deep veins of the legs due to
    - Slow flow low pressure against gravity flow
- If the thrombus dislodges it is referred to as an embolus
- Emboli are common causes of ischemic disease, particularly stroke
- Blood clots in superficial veins is known as phlebitis
  - Not as dangerous as DVT but painful
Vericose Veins

- Veins that have become enlarged and twisted.
- Usually on the legs
- Leaflet valves fail
- Retrograde gravity-driven flow leading to enlarged veins

Treating Vericose Veins

- Mild varicose veins may need no other treatment apart from surgical stockings to support the vein walls and measures to prevent them from worsening, such as exercise, weight loss, and avoiding standing for long periods. However, varicose veins can be made worse by ulcers, eczema, and swelling of the ankles. Surgery offers some improvement, although the problem may recur. Techniques such as sclerotherapy, radiofrequency, and laser techniques can be used to seal the veins, depending on their severity and location.

Lymphatic System
Heart

- Primary “pump”/“engine” for the cardiovascular system
- Meeting point for the 2 circulatory systems
  – Right side of heart (pulmonary)
  – Left side of heart (systemic)
- Has both ELECTRICAL and MECHANICAL activity
  – Electrical activity MUST precede mechanical activity

Heart Anatomy to Know

- Venae Cavae
- Pulmonary Artery
- Pulmonary Vein
- Left Atrium
- Mitral Valve
- Right Atrium
- Tricuspid valve
- Left Ventricle
- Myocardium
- Right Ventricle

Heart Valves to Know

- Aorta
- Pulmonic Valve
- Left Pulmonary Valve
- Pulmonary Vein
- Right Pulmonary Valve
Cardiac Cycle: 1. Diastole

Cardiac Cycle: 2. Atrial Systole

Cardiac Cycle: 3. Ventricular Contraction

Cardiac Cycle: 4. Systole
Gas Exchange in Lung

**Blood Pressure**
- Definition: the pressure of the circulating blood against the walls of the blood vessels.
- Two systemic blood pressure numbers:
  - Systolic (when ventricles contract – first #)
    - When pulsatile arterial pressure > cuff pressure --- “whoosh” sound with each beat
  - Diastolic (when ventricles relax – second #)
    - When (continuous) arterial pressure > cuff pressure --- loss of “whoosh” sound

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- **systolic**
- **diastolic**

**Hypertension**
- Blood pressure constantly higher than recommended levels
- No moment to moment symptoms
  - Long term effects on heart, blood vessels, vascular organs (kidney, brain, eyes etc)
  - Mechanical damage increases chances of atherosclerotic plaque leading to heart attack and stroke
- Causes of Primary Hypertension
  - Genetics
  - Dietary salt
  - Nicotine
  - Obesity
  - Alcohol
  - Stress
Listening to the Heart
(Low Technology Medicine)

- Closure of the heart valves causes the “lub-dub” sound of the heart

- “Lub” (S1 = first heart sound)
  - closure of mitral and tricuspid valves

- “Dub” (S2 = second heart sound)
  - closure of aortic and pulmonic valves

Electrocardiography (ECG, EKG)

Cardiovascular Imaging

- Radiography
- X-ray Angiography (with contrast)
- Echocardiography/Ultrasound
- Computed Tomography
  - Electron-Beam CT (EBCT)
  - Spiral CT
- MRI

Radiography
Cardiomyopathy

http://imaging.consult.com

Cardiomyopathy

Cardiomyopathy, which literally means "heart muscle disease," is the deterioration of the function of the myocardium (i.e., the muscle that makes the heart beat for any reason). People with cardiomyopathy are often at risk of arrhythmia or sudden cardiac death or both.

Cardiomyopathies can be categorized as extrinsic or intrinsic.

Cardiac Catheterization/Angiography

• Visualization of arteries/veins via injection of a contrast into the artery/vein of interest
• Uses fluoroscopy to obtain images
Color Doppler Ultrasound: Imaging Flow Direction

Color Doppler
A doppler ultrasound probe can detect the difference between blood flowing to and from the detector. This can show the blood that flows in an artery in the leg as red, and the blood in the vein as blue.

2D Echocardiogram

Computed Tomography (CT)

- Spiral (helical) CT
  - spiral shape of path of x-ray beam during scanning
  - faster than standard CT
  - desirable for vascular studies

- Electron beam tomography (EBCT)
  - No moving parts – even faster

- Usually uses dynamic imaging contrast with contrast
  - “CT Angiography (CTA)”
CT of Carotid Arteries

Examples of EBCT

CTA 3D Rendering

Stent
Imaging the heart and blood vessels with MRI

- Arteries appear as very hyperintense signal
3-Dimensional Angiographic Projections from MRI

- Projection renderings simulate conventional angiography
- Post-hoc selection of viewing perspective

MRI Contrast Reagents and T1

- Typical contrast reagents are chelates of metals ions having unpaired electron spins
- Water molecules must “touch” the agent to enhance T1 relaxation
- Molecular structure causes agent to (mostly) stay within vascular system
- Large signal enhancement in vascular system

Contrast Enhanced MRA

- Rapid (10-20 sec) T1-weighted gradient echo imaging
- Often 2 dimensional (thick slices)
- Imaging timed so that imaging coincides with arterial phase of the contrast
- Complete angiographic coverage from aortic arch to Circle of Willis
- Other peripheral vascular applications

MR Angiography (MRA)

- Projection renderings simulate conventional angiography
- Post-hoc selection of viewing perspective

MIP – Maximal Intensity Projection
Heart and Pulmonary Circulation

3D volume reconstruction
Head and Neck Vasculature
Heart Cinematic Studies

Diagnostic Power of CT

Chest CT of a 60 year old ex-smoker who volunteered for study to evaluate CT as means of screening for lung cancer