Vascular Anatomy and Physiology

Blood
Blood Clotting
Vessel Anatomy
Application of Concepts

Functions of Blood
- Transportation
  - Oxygen, CO2, nutrients and waste
- Regulation
  - pH and electrolyte concentrations

Functions of Blood
- Response to vessel injury
  - Blood clotting
- Defend against toxins and pathogens
- Assist in temperature regulation

Blood Components
- Plasma
  - Electrolytes
  - Proteins
  - Glucose
- Erythrocytes
  - Hemoglobin
  - Carries oxygen
  - Carries carbon dioxide
- Leukocytes
  - White blood cells
  - Elements of defense
  - Respond to injury, toxins, bacteria, and viruses
- Platelets
  - Fragments of erythrocytes
  - Assist with blood clotting

Blood Clotting

Events of a Tissue Injury
- Internal or external injury will stimulate a response
- Various “responders” and systems are activated
  - Histamine
  - Leukocytes
    - Phagocytes, antibodies, etc.
  - Blood clotting
Events of a Tissue Injury

- Responders flood the area to deal with the injury
- Blood clots form around the area to contain the area of damage

Steps of Blood Clotting

1) Vascular spasm
   - Immediate response
   - Minimizes initial bleeding loss

2) Platelet plug
   - Platelets drawn to the site
   - They become sticky and bind to the injured tissue as well as each other

Steps of Blood Clotting

3) Coagulation
   - Platelets stimulate the clotting factors in plasma
   - Thrombin is formed
   - Thrombin is then used to form fibrin
     - Fibrin will grow a “net” at the injury site

Coagulation, Continued

- Purpose of the fibrin “net”
  - Contains the platelets already at the site
  - Traps more platelets to build the blood clot
  - Keeps the body’s responders inside the damage zone in order to rebuild the tissue

Steps of Blood Clotting

5) Fibrinolysis
   - Eventual breakdown of the clot by plasmin
     - This occurs after more permanent tissue forms at the injured site
     - This process takes from hours-days to complete

EMS Applications of Blood Clotting
Conditions that stimulate blood clotting

- CVA and MI
  - Atherosclerotic plaque on the vessel wall tears, stimulating an injury response
  - The clot builds on top of the plaque and narrows the artery (thrombus)
  - Reduction of blood supply to the tissue surrounding the obstructed vessel

- Conditions that Stimulate Blood Clotting

  - Embolus
    - Obstruction of a vessel with a blood clot that originated in another area of the body
  - Examples
    - Pulmonary embolus from a clot generated in another area of the body in a bedridden patient
    - CVA from a clot that broke free from the right atrium in a patient with atrial fibrillation

- Conditions that Stimulate Blood Clotting

  - Severe burns
  - Systemic inflammation
    - Typically associated with massive bacterial infections
  - Bedridden patients
    - Clotting factors in the blood accumulate and stimulate spontaneous clotting

- Conditions That Delay Blood Clotting

  - Hemophilia
    - Low or missing clotting factors in the blood
  - Thrombocytopenia
    - Dysfunction with platelets in the blood
  - Causes
    - Chronic alcoholism
    - Blood transfusion reactions
    - Immune disorders (HIV and leukemia, specifically)

- Skin Signs of Dysfunctional Blood Clotting

  - Purpura and petechiae
    - Bleeding under the skin
    - Non-blanching discoloration
    - Indicates the presence of abnormal vessel permeability or damage

- Causes of Purpura and Petechiae

  - Non-life threatening
    - Chronic alcoholism
    - Advanced age
    - Chronic medication therapy
      - Steroid anti-inflammatory drugs
    - Presence of the purpura is small and limited to areas prone to injury
Causes of Purpura and Petechiae
- Potentially life threatening
  - Thrombocytopenia
- Life threatening
  - Crush injuries and traumatic asphyxia
  - Massive bloodborne bacterial infection
  - Blood transfusion reactions

Medications and Blood Clotting
- Aspirin
  - Blocks the platelet’s ability to stick together and to stimulate the clotting response
- Heparin
  - Directly inactivates the thrombin, the precursor to fibrin
- Coumadin
  - Blocks the actions of certain clotting factors in the blood
  - Indirectly blocks thrombin development

Medications and Blood Clotting
- “Clot Busters”
  - Medications used to treat AMI
  - Stimulate the development of plasmin
  - Rapid breakdown of all clotting in the body
- “Clot buster” names
  - Streptokinase
  - Urokinase
  - Tissue plasminogen activator (t-PA)

Blood Vessel Anatomy and Physiology

A little anatomy

Vessel Anatomy
- Outer layer
- Elasticity
- Middle layer
- Muscle
- Vasoconstriction
- Inner layer
- Lumen of the vessel
**Vessel Wall Comparisons**

**Artery and Vein Comparisons**

**The Capillary**
- Wall structure
  - 1 cell layer thick!
  - No muscular layer
  - Porous
  - Site of gas exchange
  - Exchange is based upon pressure changes within the capillary bed

**Capillary Sphincters**
- Muscular bands at the entrance and exit of the capillary bed
- Controls fluid movement to the cells

**Capillary Blood Flow**
- Opening/closing of sphincters will change the pressure between the capillary and the cells
- This assists with gas exchange
- Control of capillary sphincters
- Changes in O₂ and CO₂ levels
- Changes in pH
- Sympathetic NS stimulation

**Blood Flow**
- Getting blood to the cells is a result of several factors
  - Cardiac output
  - Preload
  - Contractility
  - Afterload
  - Resistance to blood flow
  - Turbulence
  - Viscosity of the blood
Blood Flow
- Blood flow may be measured in part by blood pressure
  - \( BP = \text{cardiac output} \times \text{peripheral vascular resistance (PVR)} \)
- The greatest amount of PVR occurs at the arteriole and capillary level

Control of Capillary Sphincters
- Stimulation by the sympathetic nervous system
  - Closure of precapillary sphincters in the periphery
  - Diverts blood to core organs
- Concentrations of oxygen and carbon dioxide
  - Opening and closing to increase oxygen delivery and remove wastes quickly

Blood Pressure Regulation
- Feedback loops
  - Similar use of the medulla and input from chemoreceptors and baroreceptors as the heart
- Response of the medulla
  - Autonomic nervous system
    - Sympathetic nervous system
      - Increase in BP by increasing both cardiac output and PVR

Response of the Medulla
- Chemical controls for increasing BP
  - Epinephrine and norepinephrine from the adrenal gland
    - Similar effects as the sympathetic nervous system
    - Longer-lasting effects
  - Anti-diuretic hormone
    - Stimulated in response to low fluid or electrolyte levels
    - Retains water at the kidneys
    - Causes vasoconstriction

Application of Blood Flow and Perfusion

Hypovolemia
- Fluid loss = drop in pressure in the vessels
- Hormones released to stop water loss in the kidneys
- Response of the sympathetic nervous system
  - Closing of capillary sphincters in the periphery
  - Vasoconstriction
  - Increase in cardiac output
    - Increased HR and contractility
Dehydration
- Impacts on Perfusion
  - Thickens blood
  - Changes electrolyte concentrations
  - Increases the viscosity of blood
  - Reduced preload to the heart
- Compensation
  - Baroreceptors stimulated
  - Sympathetic NS
  - ADH

Heart Attack
- Impacts on Perfusion
  - Tissue damage = reduction in contractility
    - Reduction of stroke volume
    - Reduction in cardiac output
- Compensation
  - Baroreceptors and chemoreceptors sense low pressure and oxygen delivery
    - Stimulate the sympathetic nervous system
      - Increase in vasoconstriction
      - Stimulate the heart to beat faster and harder

Vascular Disorders
- Chronic Hypertension
- Hypertensive Emergency
- Aortic Aneurysm

Hypertension Pathology
- Constriction of the arteries/arterioles
- Sympathetic nervous system response
  - Stress
  - Stimulants
  - Cold medicines

Hypertension Pathology
- Increased pressure inside of the arteries/arterioles
  - Significant fluid shifts into the vessels
    - Pre-eclampsia (toxemia of pregnancy)
    - Chronic fluid retention
      - CHF
      - Kidney failure

Hypertension Pathology
- Review of arterial wall structure
- Chronic Consequences
  - CVA
  - Aortic aneurysm
  - CHF and acute pulmonary edema
  - Renal failure
Causes of Acute Hypertension
- Toxemia of pregnancy
- Non-compliance with anti-hypertensive medications
  - “Hypertensive emergency”
- Increased intracranial pressure
  - Head trauma
  - CVA

Hypertensive Emergency
- Any sudden increase in BP
  - Diastolic typically rises above 100-115 mmHg
- History of hypertension
- Precursors
  - Change in BP meds
  - Change in BP med doses
  - Stoppage of BP meds

Hypertensive Emergency
- Symptoms:
  - Blurred Vision
  - Confusion
  - Headache
  - Slurred speech
  - Acute pulmonary edema
  - Weakness
  - Nausea/vomiting
  - Weak bilateral grips

  - Presentation may be similar to a CVA
    - Signs and symptoms are typically bilateral
    - A thorough history must be performed to differentiate the two

Narrowing the causes of high blood pressure
- CVA, TIA
  - Unilateral symptoms and signs
    - 1-sided arm drift, leans to one side, 1-sided facial droop
- Intracranial bleed
  - History of recent trauma
  - History of brain aneurysms
- Hypertensive Emergency
  - Previous episodes
  - Change in anti-hypertensive medication or dose

Treatment of Hypertensive Emergency
- Nitroglycerin
  - Systemic vasodilation
  - 0.4mg every 3-5 minutes
    - Reassess blood pressure and neurological signs every 3-5 minutes as well
- Morphine sulfate
  - Systemic vasodilation
  - May lower consciousness

Aortic Aneurysm
- Abnormal balloononing of the aorta
- Weakening of interior walls
- Blood accumulation between the internal layers
Aortic Aneurysm

- Contributing factors
  - Atherosclerosis
  - Hypertension
  - Trauma
- Development may be slow
- Patient may be asymptomatic

Aortic Dissection

- Pathophysiology
  - Further tears between the arterial walls
  - More blood accumulation in the middle layer
  - Increased pressure may cause a rupture of the outer wall

Patient Presentation

- Signs of shock
  - Near-syncope
  - Orthostatic changes to vital signs
  - Unequal pulses/blood pressure readings in extremities
- Sudden, severe, pain
  - Tearing or stabbing in the abdomen or back
  - Radiation to groin, back, lower back
- Abdominal rigidity or pulsating mass
- Nausea or vomiting

Management

- High-flow oxygen
- IV therapy
  - Titration of fluids
    - Patient mentation
    - Systolic blood pressure of 90-100mmHg
- Transport considerations
  - Facility with surgical capabilities

THE END