Blood: The River of Life

Human Anatomy & Physiology
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Blood: Only Fluid Tissue
Two components
- Formed elements
  - Leukocytes (WBC) and platelets (buffy coat) equal less than 1% of blood
  - Erythrocytes (RBC) equal 45% of blood
    - Aka. Hematocrit = measure of RBC present
    - Plasma (fluid portion) = 55% of blood

Blood Information
- pH = 7.35 – 7.45
- Temperature = 38°C or 100.4°F
  - Slightly higher than body temp.
- Approx. 8% of body weight
  - Males have 5-6 L while females have 4-5 L although amount depends on size
- Color
  - Oxygen rich blood is scarlet red
  - Oxygen poor blood is dull or rusty red
  - Blood is heavier & more viscous than water

Carbon Monoxide Poisoning
- Symptoms:
  - Headache, nausea, achy – a lot like the flu
  - Convulsions & unconsciousness as levels increase
  - Even though oxygen level is low – person looks very flushed – NOT cyanotic
Functions of Blood

- **Transport:**
  - Oxygen
  - Waste products incl. Carbon dioxide
  - Hormones
  - Heat

- **Maintenance**
  - Normal pH
  - Adequate fluid volume

Functions of Blood

- **Prevention:**
  - Blood loss through clotting mechanisms
  - Infection through white blood cells
  - Example: engulfing TB bacteria

Erythrocytes

- **Structure:**
  - Few organelles
  - Lack mitochondria
  - Don’t do aerobic respiration so don’t use up the oxygen that they are carrying

- **Anucleate**
  - Only survive ~120 days

RBC proteins

- **Hemoglobin**
  - 33% of cell weight
  - Carries oxygen on iron atoms

RBC Proteins
RBC Proteins

- Spectrin
  - to maintain membrane integrity and change cell shape so cell can travel without rupturing as it squeezes through capillaries
- Misc. other proteins help with facilitating gas exchange and other functions

Biconcave shape increases surface area to volume ratio for gas exchange

Numbers of RBCs

- Outnumber WBC 1000 to 1
- Women
  - 4.3 – 5.2 million RBC per mm³ of blood (about 1 small drop)
- Men
  - 5.1 – 5.8 million RBC per mm³ of blood
  - women typically have a lower percentage of RBC which is why they tend to have trouble with Anemia
- # of blood cells compared to amount of plasma is major factor in blood viscosity
  - If blood is too viscous – heart must work too hard to pump it

Anemia vs. Polycythemia

Functions of RBCs

- Major function is to carry oxygen
- Single RBC contains ~250 million hemoglobin molecules each capable of carrying 4 oxygen atoms

Hemoglobin

- Protection of hemoglobin
  - Enclosed in RBC to prevent fragmentation which would increase blood viscosity
- Reminder:
  - If blood is too viscous – heart must work too hard to pump it
Hematopoiesis

- Hematopoiesis: Blood cell formation
  - Occurs in red bone marrow (myeloid) which is found in the ends of long bones and in flat bones
- Stem Cell is called Megakaryocyte
- Hemocytoblasts convert to hemocytes
  - Cycle takes 3-5 days

Erythropoiesis

- Erythropoiesis: Red blood cell formation
  - Based on oxygen demands by body
    - Hypoxia: too few RBCs = oxygen deprivation
    - Too many (polycythemia) = blood viscosity increases
  - Average production rate = 2 million/sec
  - Controlled hormonally
    - Based on level of available oxygen
    - triggers erythropoietin production in kidney

Erythropoiesis

- Production depends on:
  - Fe, vitamin B12, and folic acid
    - Necessary for DNA synthesis and hemoglobin synthesis

Life Cycle of RBCs

- After 120 days, the RBC is degraded and recycled by Macrophages (cleanup crew)
- Hemoglobin is broken down to bilirubin
  - Goes to liver to be excreted
  - Liver damage can cause jaundice affecting many body organs
  - Review: Bilirubin excess in brain causes kernicterus
Leukocytes (WBCs) – body defense system

- 4000 – 11,000 per mm$^3$
- Complete cells with nuclei and various organelles

Leukocyte Special Characteristics

- Diapedesis
  - Reach infection site by slipping into and out of blood vessels
- Ameboid motion
  - Move through tissue spaces to reach location
- Chemotaxis
  - Respond to chemicals released by damaged cells in order to locate damaged area

Leukocytes-Granulocytes

- Contain specialized granules and lobed nuclei

Neutrophils

Active phagocytes – attracted to inflammation through chemotaxis
- Numbers increase during bacterial & fungal infections
- Produce white/yellow pus and snot & mucus
Basophils

- Basophils
  - Located in certain tissues – aka. Mast cells
  - Increase in # during allergy attacks
  - Produce heparin & histamine to cause vasodilation and attract other WBCx to area of attack
  - Produce clear watery snot

Eosinophils

- Located in intestinal & pulmonary mucosa and in dermis
- Increase in number during
  - Parasitic infestations and produce chemicals to counteract allergic reactions
  - Produce greenish snot

Leukocytes-Agranulocytes

- Lymphocytes
  - 3 types that play an immune system role
    - (B-cells, T-cell, and Natural Killer cells)
    - T-cells (several types)
      - Attack virus infected & tumor cells
    - B-cells (several types)
      - Produce antibodies (immunoglobulins) for long term immunity

- Monocytes

Leukocytes

- Lack granules
- Formed in bone marrow and then migrate to lymphatic tissues – rarely circulate in blood unless needed
- 2 types
**Natural Killer Cells**

**Leukocytes**

- Monocytes
  - Very mobile, aggressive macrophages
  - Increase in number during chronic infections (such as tuberculosis) and act against viruses and bacteria in long term infections
  - Activate lymphocytes to start immune response

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**Leukopoiesis**

- Activated by specific chemicals in response to infections, toxins, tumor cells, etc.
- Granulocytes produced and stored in **bone marrow** as needed
- Granulocytes have short life span - .5 to 9 days – die fighting invaders
- Agranulocytes may live days to years depending on type

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**Plasma**

- Straw colored, sticky fluid matrix
- 90% water - 10% dissolved proteins, gases, wastes, etc.
- Plasma proteins produced by liver: know functions:
  - Albumin – water balance
  - Fibrinogen - clotting
  - Alpha & beta globulins - transport
  - Gamma globulins - immunity
- Homeostatic levels maintained by various organs

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**Platelets (Thrombocytes)**

- Formed by megakaryocytes (stem cells)
- Fragments of cells that clump together to form a seal at damaged BV locations
- Not a complete cell – lack nuclei and organelles so short life span

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**Bone Marrow**

- **White Blood Cells**
  - Fight Infection
- **Red Blood Cells**
  - Carry Oxygen
- **Platelets**
  - Control Clotting
End of Quiz #2 Material

Clot formation

Steps of Hemostasis

- Platelet plug formation
  - Normally, platelets and endothelium are both positively charged so they repel each other and the endothelial wall of BV
  - When endothelium ruptured, platelets contact negative collagen fibers
  - Chemical changes cause platelets to swell and stick together and to the wall
  - Chemicals are released to attract more platelets to seal cuts
  - Platelet plug is formed – effective in sealing small vascular nicks

Aspirin

- Aspirin inhibits platelet plug formation and prolonged bleeding may occur
  - In small doses, it inhibits unnecessary clotting thus preventing heart attacks & strokes
- Aspirin is an anticoagulant

Steps to Hemostasis

- Vascular Spasms
  - initiated by serotonin released from anchored platelets and stimulation of local pain receptors cause BV to spasm
  - vasoconstriction narrows BV decreasing blood loss

Steps to Hemostasis

- Coagulation – blood clotting
- Critical events that occur:
  - Thromboplastin released by injured tissue
  - interacts with prothrombin activator (PF3)
  - Which converts prothrombin to thrombin
  - Which joins fibrinogen molecules into a fibrin mesh
  - Which traps RBCs and pulls edges closer together
Hemostasis

- Medical Animation Library: Blood Clotting

More than 30 substances involved
- Procoagulant – promotes clotting
- Anticoagulant – inhibits clotting

Homeostasis

- When body is in homeostasis – there are several mechanisms that prevent clotting when it should NOT occur and enhance clotting when it SHOULD occur.

Fibrinolysis (clot busting)

- When normal cell regeneration begins, clot becomes unnecessary
- Plasmin (clot buster) is released until clot is dissolved totally.
- Release typically begins within 2 days and continues until clot dissolved

End of Quiz #3 Material
Blood Groups

- RBCs contain antigens (glycoproteins) for cell recognition
  - 30 common varieties - over 100 “family antigens”
  - common antigens - ABO and Rh cause vigorous transfusion reactions
  - others mainly used for ID purposes (paternity, inheritance, etc.) - only typed in cases of several transfusions (cumulative effect)
- ABO blood groups
  - based on presence or absence of A or B antigens on RBCs
  - plasma antibodies act against foreign antigens not present on that individual’s RBCs
  - see chart

Rh factor

- Rh+ 85% of Americans - carry Rh antigen on RBC
- Rh- don’t have antigen on RBC
- Rh- can go into Rh+ BUT Rh+ cannot go into Rh-
- less severe transfusion reaction (hemolysis of donor RBCs) - doesn’t usually occur until 2nd transfusion due to body’s reaction time

In Pregnant Women

- can cause erythroblastosis fetalis (hemolytic disease of the newborn)
  - if Rh- woman carries Rh+ baby
    - 1st baby is usually okay due to reaction time unless there was a bleeding problem during the pregnancy or a previous miscarriage or abortion.
    - 2nd baby will have its blood cells attacked by mother’s antibodies.
    - Rhogam shot can prevent this if injected at 28 weeks of pregnancy and again right after birth.
Transfusions

- In case of blood loss, body tries to:
  - reduce BV volume to maintain circulation to vital organs
  - step up production of RBCs for replacement
- 15-30% loss - pallor & weakness
- over 30% - severe shock may be fatal
- substantial blood loss - whole blood transfusion
- Plasma, electrolyte solutions (Ringer’s solution) etc. can be used to increase blood volume while body steps up production of RBCs
- Whole Blood transfusions can be given but blood must be typed and matched to prevent transfusion reaction

Transfusion Reaction

- Mismatched RBCs antigens attacked by plasma antibodies
- agglutination of foreign RBCs can:
  - clog small BV - reduce blood flow
  - lysed RBCs release hemoglobin into blood-reduced oxygen capacity - blocks kidney tubules and causes renal shutdown
- Reactions: fever, chills, vomiting
- Treatment: alkaline fluids to dilute hemoglobin, diuretics to increase urine flow to flush kidneys

Know the information contained in this chart

<table>
<thead>
<tr>
<th>Rh positive</th>
<th>Rh negative</th>
<th>Blood Type</th>
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<tbody>
<tr>
<td>A</td>
<td>Anti-B</td>
<td>A</td>
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<tr>
<td>B</td>
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<tr>
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Agglutination