Clinical Laboratory Studies

CRC 330
Cardiorespiratory Care
University of South Alabama
Introduction

- Proper cardiopulmonary assessment includes basic laboratory studies
- Hematology, chemistry, microbiology, BAL, pleural fluid, urine, histology, skin testing, and arterial blood gases
- Indications for tests, normal and abnormal values and clinical correlations
- “a diagnosis is seldom made from the results of a laboratory test alone”
Blood

Formed elements
- White blood cells (Leukocytes)
- Red blood cells (Erythrocytes)
- Platelets (Thrombocytes)

Plasma
- electrolytes
- clotting factors
- immunologic factors
- proteins
- lipids
- hormones
- remove clotting factors: serum
Hematology

- White blood cell count
  - Function in the immune system
  - Normal: 4,500-11,500/mm$^3$
  - Elevated in infectious disease, associated with fever and sepsis, steroid administration
  - Very common, therapeutically useful
Hematology

- **White blood cell differential**
- **Neutrophils (segs and bands)**
  - 40-75% of WBCs
  - destroy bacteria
  - may release enzymes and mediators at the endothelium to cause ARDS
  - Bands increase in severe infection
  - phagocytic
- **Eosinophils**
  - allergic reactions and parasitic infestation
  - 0-6% of WBCs
Hematology

- **Basophils**
  - allergic reactions
  - 0-1% of WBC

- **Lymphocytes**
  - T-cells for cell mediated immunity
  - B-cells for antibody production
  - 20-45% of WBCs

- **Monocytes**
  - macrophage for the blood, phagocytic
  - 2-10% of WBCs
Blood Cell Differential
Hematology

- **White cell abnormalities**
  - Leukocytosis: increased total WBC count
  - Leukopenia: decreased total WBC count, often associated with chemotherapy and radiation therapy
  - Neutrophilia
    - increase in neutrophils, seen in infection
    - accompanied by increased bands (young cells)
    - correlates with infection
  - Eosinophilia: allergic responses, asthma
  - Lymphocytosis: viral infections, mononucleosis
  - Monocytosis: chronic infection: TB, syphilis
  - Lymphocytopenia: trauma, acute infection, HIV
Hematology

- RBCs
  - made in the bone marrow, no nucleus, last 120 days
  - main function is to carry oxygen
  - normal value is 4.6-6.2x10^6/mm³ in men, 4.2-5.4x10^6/mm³ in women
  - decreased in anemia, decreased oxygen carrying capacity
Hematology

- **Hematocrit**
  - % of RBCs in a sample of whole blood
  - 40-54% in men, 38-47% in women
  - HCT/3.3=Hb

- **Hemoglobin**
  - oxygen carrying pigment
  - 13.5-16.5 g/dl in men, 12-15 g/dl in women
  - 1.34 vol% of O2 carried by each gram of Hb

- \[ CaO_2 = (1.34 \times Hb \times SaO_2) + (PaO_2 \times 0.003) \]
Hematology

- Polycythemia
  - increased RBC, Hb, Hct
- Primary polycythemia
  - rare, uncontrolled proliferation of hematopoietic cells
- Secondary polycythemia
  - chronic stimulation of bone marrow, secondary to other disease
Hematology

- Secondary polycythemia
  - COPD, OSA, pulmonary fibrosis, altitude, heavy smoking
  - due to chronic hypoxemia stimulating renal production of erythropoietin in turn stimulating bone marrow to produce more RBCs
- Increases blood viscosity, leading to decreased flow and embolism
Hematology

- Platelets
  - form blood clots
  - normal value: 140-440 x $10^3$/mm$^3$
  - if < 50 x $10^3$/mm$^3$, bleeding problems (disseminated intravascular coagulopathy), skin hemorrhages
  - thrombocytopenia
  - increased in bone marrow diseases, increased tendency to clot
Charting Hematology

- WBC
- HGB
- HCT
- PLT
Coagulation Studies

- Activated partial thromboplastin time (APTT, PTT)
  - evaluates intrinsic pathway that is activated by endothelial damage, resulting in formation of fibrin clot
  - normally 24 - 32 sec.
- Prothrombin time (PT)
  - normally 12 - 15 sec.
  - PT/INR normal is <1.2 (international normalized ratio)
  - used to evaluate the presence of clotting factors
- APTT is used to monitor heparin therapy, PT is used to monitor Coumadin (warfarin)
  - INR should be 2-3
Electrolytes: Sodium

- Normal: 137-147 mEq/L
- Responsible for the osmotic pressure extracellular fluid, regulated by aldosterone and ADH
- Hypernatremia - water loss without salt
  - Causes: sweating, diarrhea, renal disease, lack of water intake
  - Symptoms: excessive thirst, dry sticky mouth
- Hyponatremia - excess sodium loss compared to water loss
  - Causes: diarrhea, nephrosis, diuretic therapy
  - Symptoms: confusion, abnormal sensorium, muscle twitching, seizures
Electrolytes: Potassium

- Normal: 3.5 – 4.8 mEq/L
- Hypokalemia - low extracellular concentration
  - when fluid is lost containing K
  - Causes: kidney disease, vomiting, diarrhea, diuretic therapy, metabolic alkalosis
  - Symptoms: weak, rapid, irregular pulse, muscular weakness
- Hyperkalemia
  - Causes: metabolic acidosis, tissue damage,
  - Symptoms: weakness, fatigue, nausea, muscle paralysis
Electrolytes: Chloride

- **Normal**: 98-105 mEq/L
- **Hypochloremia**
  - caused by vomiting (acid loss), respiratory acidemia
- **Hyperchloremia**
  - dehydration, prolonged diarrhea
Bicarbonate

- Bicarbonate (HCO₃⁻), serum anion
  - Normal: 22-26 mEq/L
  - Very important in acid-base balance, since it carries 90% of the CO₂
  - Increased in metabolic alkalosis, decreased in metabolic acidosis
Anion Gap

- Quantifies unmeasured anions
- Excessive anion gap indicates metabolic acidosis
- $AG = Na - (bicarb + Cl)$
- Causes of increased AG include lactic acid, ketoacids, sulfates, poisons (aspirin overdose)
Increased Anion Gap Indicates:

- Lactate (liver disease, tissue hypoxia)
- Ketones (diabetic and alcoholic ketoacidosis)
- Salicylates
- Phosphates and sulfates
- Uremic acidosis
- Formate
- Glycolate and oxylate
- Ethylene glycol
- Free fatty acids
- Methyl malonate
Sweat Chloride

- > 60 mEq/L of Na or CL indicates cystic fibrosis
- Pilocarpine iontophoresis
  - Pilocarpine is applied to the skin, f/b weak electric charge to induce sweating
  - Area is wiped and the medium is analyzed for chloride
- **For infants up to and including 6 months of age, a chloride level of:**
  - Equal to or less than 29 mmol/L = CF is very unlikely
  - 30 - 59 mmol/L = intermediate means that CF is possible
  - Greater than or equal to 60 mmol/L = CF is likely to be diagnosed
- **For people older than 6 months of age, a chloride level of:**
  - Equal to or less than 39 mmol/L = CF is very unlikely
  - 40 - 59 mmol/L = intermediate means that CF is possible
  - Greater than or equal to 60 mmol/L = CF is likely to be diagnosed
Chemistry: Blood Urea Nitrogen

- Normal: 7-20 mg/dl
- Urea is a waste product synthesized by the liver from nitrogen
- Increased BUN often due to kidney disease, due to decreased filtration and increased retention of nitrogen
- Associated with shock and heart failure
- Commonly used to assess extent of renal disease
Chemistry: Creatinine

- Normal: 0.7-1.3 mg/dl
- Waste product formed by muscle tissue, filtered by kidneys
- Increased in kidney disease in which 50% of the nephrons are destroyed; muscle diseases
- Often accompanied by metabolic acidosis and SOB
Charting Chemistry

Na  HCO₃  BUN

K  Cl  Creat

Gluc
Chemistry: Enzymes

- Aspartamine aminotransferase (AST)
- Alanine aminotransferase (ALT)
- Alkaline phosphatase (ALP)
- Acid phosphatase (ACP)
- Lactate dehydrogenase (LDH)
- Creatine kinase or Creatine phosphokinase (CPK)
- Amylase and Lipase
- Troponin
Glucose

- The major nutrient used to produce energy via the Krebs cycle
- Insulin is produced by the pancreas for glucose metabolism
- Type I diabetes is the failure of the pancreas to make insulin
- Type II diabetes is the result of insulin resistance
- Normal fasting glucose is 70-105 mg/dl
Glucose

- **Hyperglycemia**
  - related to type II diabetes
  - steroids can blunt the insulin response to glucose, resulting in steroid-induced diabetes

- Hyperglycemia associated with acidosis caused by accumulation of ketoacids is ketoacidosis, which is treated emergently with insulin

- **Hypoglycemia**
  - caused by excessive insulin in the blood
  - symptoms are sweating, shaking, weakness, headaches, lethargy, coma
Chemistry: Protein and Albumin

**Albumin**
- protein that transports and stores hormones, drugs and electrolytes
- maintains oncotic pressure of blood
- hypoalbuminemia is caused by protein malnutrition and severe liver disease

**Total protein**
- rough screening test to detect gross abnormalities in protein synthesis
- decreased in severe liver disease, nephrotic syndrome and severe malnutrition
Microbiology

Pulmonary secretions

- Obtain a valid sample
  - patient must rinse mouth and/or brush teeth
  - deep cough to produce sputum vs saliva or nasal secretions
  - sputum induction
- Yellow or green sputum
  - allergic or infectious process
  - green sputum assoc. with pseudomonas aeruginosa
- Examined for microorganisms, abnormal cells
# Pleural Fluid Analysis

<table>
<thead>
<tr>
<th>Clue</th>
<th>Exudate</th>
<th>Transudate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Cloudy, viscous, yellow-tinged, clots on standing</td>
<td>Clear, thin, non-clotting</td>
</tr>
<tr>
<td><strong>Protein content (g/dL)</strong></td>
<td>&gt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td><strong>Pleural fluid:serum LDH</strong></td>
<td>&gt;0.6</td>
<td>&lt;0.6</td>
</tr>
<tr>
<td><strong>Causes</strong></td>
<td>Infection, tumor, trauma, embolic disease</td>
<td>CHF, renal failure, cirrhosis</td>
</tr>
<tr>
<td><strong>Inflammatory cells</strong></td>
<td>some</td>
<td>few</td>
</tr>
</tbody>
</table>
Appearance of Pleural Fluid

Transudate  Exudate
Skin Testing

To test for

- TB
- allergies
- coccidioidomycosis, blastomycosis
- sarcoidosis
- Small amount of allergen or substance is placed on the skin with a pin prick, scratch, or injected subcutaneously
- For TB, purified protein derivative (PPD) is injected
  - read 48-72 hrs later
  - appearance of a wheal indicates a positive reaction
- medical history may affect reaction (such as hx of BCG)