LAB VALUES

What do they all mean?

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It All Begins With Specimen Collection

What type of sample do you need?
Blood: Serum or Plasma/Whole Blood

Gold, Red tubes = Serum = Clotted sample
Blue, Lavender, Mint, Gray, Yellow tubes = Plasma = Anticoagulated sample
Specimen Collection continued

- Follow Order of Draw
  Yellow, Blue, Red, Green, Lavender, Gray
- Fill tubes to draw line
- Blood Conservation
- Specimen In Lab (SIL)
Collection Problems

**Hemolysis**

Common causes include:

- Using a small needle (23 g and above)
- Too vigorous mixing
- Forcing blood from a syringe into a tube
- Applying tourniquet too close to puncture site
- Not letting alcohol dry
- Collecting blood while starting an IV
Collection Problems continued

- Clotted Samples
- IVs
- Hemoconcentration
- Questions?
Laboratory Tests Commonly Utilized to Evaluate Anemia

- Complete Blood Count (CBC)
- Reticulocyte Count (% and #)
- Hemoglobin Electrophoresis
- Iron Studies: Serum Iron (Fe), TIBC, % Saturation, Ferritin, Transferrin, and Soluble Transferrin Receptor
- Erythropoeitin (EPO)
- Folate
- Vitamin B12
- Prealbumin
## Ordering Hematology Tests

<table>
<thead>
<tr>
<th>TEST</th>
<th>AKA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Blood Count</td>
<td>CBC Only</td>
</tr>
<tr>
<td>CBC with Differential</td>
<td>CBC with Diff</td>
</tr>
<tr>
<td>Reticulocyte Count</td>
<td>Retic</td>
</tr>
<tr>
<td>Hemoglobin Electrophoresis</td>
<td>HgbEP</td>
</tr>
</tbody>
</table>
Complete Blood Count

- White Blood Cells (WBC)
- Red Blood Cells (RBC)
- Hemoglobin
- Hematocrit
- Mean Corpuscular Hemoglobin (MCH)
- Mean Corpuscular Volume (MCV)
- Mean Corpuscular Hemoglobin Concentration (MCHC)
- Red Cell Distribution Width (RDW)
- Platelet Count (PLT)
- Mean Platelet Volume (MPV)
Red Blood Cells

- Also referred to as erythrocytes
- Contain hemoglobin
- Primary function is to transport Oxygen throughout body
- Average life span 120 days
Red counts and Hemoglobin

Red cell Reference ranges

- Males: 4.4 – 5.5 mil/uL
- Females: 4.0 – 5.0 mil/uL

Hemoglobin Reference ranges

- Males: 13.5 – 16.5 g/dL
- Females: 12.0 – 15.0 g/dL

- Cutoff Diagnosis of Anemia
  - Males: <13.5 g/dL
  - Females: <12.0 g/dL
Hemoglobin

- Readily combines with oxygen to form oxyhemoglobin
- Responsible for the transport of oxygen and carbon dioxide between the lungs and body tissues
Hematocrit

- Packed cell volume of erythrocytes in a given volume of blood
- Reference ranges
  - Males: 40 - 50%
  - Females: 36 - 45%
- Cutoff Diagnosis of Anemia
  - Males: <40%
  - Females: <36%
Rule of Three

- There is a relationship between the Red Blood Cell Count, Hemoglobin, and Hematocrit.
- Normally these three values follow the rule of three:
  - The hemoglobin should be three times the red count.
  - The hematocrit should be three times the hemoglobin.

Example: RBC = 5.00, HGB = 15.0, HCT = 45
Erythrocyte Indices

- Calculated values based on RBC, HGB, HCT, MCV
- Classifies the Red Blood Cells as to their size and hemoglobin content
- Abnormal RBC morphology characteristic of distinct types of anemia therefore indices are useful for classification of anemic states
Erythrocyte Indices continued

- Mean Corpuscular Hemoglobin (MCH)
- Mean Corpuscular Volume (MCV) size
- Mean Corpuscular Hemoglobin Concentration (MCHC)
Mean Corpuscular Hemoglobin (MCH)

Average content of hemoglobin in individual RBCs

- MCH = HGB X 10/RBC
- Measured in picograms (pg)
- Reference range 26 – 34 pg
- Does not take cell size into consideration
- Should be interpreted in relation to MCV
Mean Corpuscular Volume (MCV)

Average size/volume of individual RBCs

- \( \text{MCV} = \frac{\text{HCT}}{\text{RBC}} \times 1000 \)
- \( \text{RBC} \times \text{MCV} = \text{HCT} \)
- Measured in femtoliters (fL)
- Reference range 80 – 100 fL
MCV continued

• Classification of cells
  – Normocytic 80 – 100 fL
MCV continued

- Classification of cells
  - Microcytic    $<80 \text{ fL}$
MCV continued

- Classification of cells
  - Macrocytic $>100 \text{ fL}$
Mean Corpuscular Hemoglobin Concentration (MCHC)

- Average concentration of hemoglobin in a deciliter of RBCs
- $\text{MCHC} = \frac{\text{HGB}}{\text{HCT}}$
- Measured in grams/deciliter (g/dL)
- Reference range 32 – 36 g/dL
MCHC continued

• Classification of cells
  – Normochromic 32 – 36 g/dL
MCHC continued

- Classification of cells
  - Hypochromic <32 g/dL
MCHC continued

- Classification of cells
  - Hyperchromic >36 g/dL
Red Cell Distribution Width (RDW)

- Index to identify RBC size variation (anisocytosis)
- Reported as a percent (%)
- Increased = greater variation of cell size
- Reference range 11 – 15 %
Reticulocyte Count

- Reticulocyte, Percent (%)
  Percentage of reticulocytes in relation to total RBC count

- Reticulocyte, Absolute (#)
  Estimation of reticulocyte production
Reticulocyte continued

• Immature RBCs; contain RNA
• Stain with New Methylene Blue

Used to:
• Evaluate effectiveness of bone marrow activity
• Used to monitor anemia and response to therapy
Reticulocyte continued

Reference ranges
- % Reticulocyte
  • 0.5 – 2.0%
- # Reticulocyte
  • 30 – 94 th/uL

Looking for value >2.0
## Case studies

<table>
<thead>
<tr>
<th>TEST</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC=3.10</td>
<td>4.0-5.0</td>
</tr>
<tr>
<td>Hgb=8.9</td>
<td>12-15</td>
</tr>
<tr>
<td>RDW=20.3</td>
<td>11-15</td>
</tr>
<tr>
<td>Reticulocyte Count =7.8%</td>
<td>0.5-2.0%</td>
</tr>
</tbody>
</table>
## Case studies

<table>
<thead>
<tr>
<th>TEST</th>
<th>Normal</th>
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</thead>
<tbody>
<tr>
<td>RBC= 1.42</td>
<td>4.0-5.0</td>
</tr>
<tr>
<td>Hgb= 5.8</td>
<td>12-15</td>
</tr>
<tr>
<td>RDW= 34.2</td>
<td>11-15</td>
</tr>
<tr>
<td>Reticulocyte Count = 36%</td>
<td>0.5-2.0%</td>
</tr>
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</table>
Tests for Iron

- Serum Iron (Fe)
- TIBC
- % Saturation
- Ferritin
- Transferrin
- Soluble Transferrin Receptor
Iron (FE)

- Required by every cell in body
- Vital roles in oxidative metabolism, cellular growth and proliferation, and in oxygen transport and storage
- Must be bound to protein compounds
- Functional Iron is present in Hemoglobin
- Hemoglobin constitutes major fraction of body iron with concentration of 0.5 mg/mL blood
- Total Iron concentration in body = 40 – 50mg/kg of body weight
Transferrin

Transferrin = Iron transport protein

- Mediates iron exchange between tissues
- Delivers recycled iron (85% of all iron) to developing normoblasts in bone marrow for heme synthesis
- One gram will bind 1.4 mg iron
- 95% of all iron is complexed with transferrin
- Transferrin is 1/3 saturated with iron
Total Iron Binding Capacity (TIBC) and % Saturation

- Total Iron Binding Capacity
  \[ TIBC = \text{Maximum amount of iron that can be bound to transferrin} \]

- % Saturation
  \[ % \text{ Sat} = \frac{\text{Serum Iron}}{\text{TIBC}} \]
  \[ \text{or} \]
  \[ % \text{ Sat} = \frac{\text{Serum Iron}}{\text{Transferrin}} \times 1.2 \]
Ferritin

Ferritin = Primary storage compound for iron

- Iron is absorbed through mucosal cells and bound to apoferritin
- Readily available for erythropoiesis
- Found in bone marrow, liver, and spleen
- Depletion reflects excess iron loss over what is absorbed
- No diurnal variation (unlike iron)
Ferritin continued

- Directly proportional to amount of storage iron in body
- Decrease is first indication of developing iron deficiency anemia
- Levels become abnormal before exhaustion of mobilizable iron stores
- Acute phase reactant
Ferritin continued

Ferritin

– Changes in total body storage iron are accompanied by fluctuations in the serum iron and TIBC
– Decreased Ferritin = Serum FE Decrease and TIBC Increase

– Ferritin < 12 ug/L = Depletion of Iron Stores
– Ferritin >1000 ug/L = Iron Overload
Soluble Transferrin Receptor (STFR)

STFR – formed when transferrin releases iron into the cells
- Not an acute phase protein
- Useful when ferritin is high due to inflammation
- Inversely related to iron status

STFR increases with iron deficiency
STFR decreases in response to iron repletion
Iron Testing – Reference Ranges

- Serum iron  
  M: 30 – 300 ug/dL  
  F: 50 – 130 ug/dL
- TIBC: 270 – 380 ug/dL
- % Saturation: 28 – 42%
- Ferritin  
  M: 30 – 300 ng/mL  
  F: 10 – 200 ng/mL
- Transferrin: 185–336 mg/dL
- STFR: 1.8 – 4.6 mg/L
# Ordering Iron Testing

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<td>Serum Iron</td>
<td>IRON</td>
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<tr>
<td>Transferrin</td>
<td>Transferrin</td>
</tr>
<tr>
<td>Ferritin</td>
<td>Ferritin</td>
</tr>
<tr>
<td>Iron Study</td>
<td>Serum Iron, TIBC, % Saturation</td>
</tr>
<tr>
<td>Soluble Transferrin Receptor</td>
<td>STFR</td>
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Erythropoietin (EPO)

- Only cytokine to function as a true hormone
- Found in cells of kidney
- **Travels to bone marrow to influence erythrocyte production**
- Release regulated by oxygen need of body or hypoxia
EPO continued

- Reference range 4 – 20 mIU/mL
- EPO increases when HGB decreases below 12g/dL
- EPO significant because reflects production as well as utilization by bone marrow (disappearance from blood)
- Response to anemia – Generally increased except in anemia of renal disease
Folate

- Folate = Folic Acid
- Important for normal embryogenesis
  - Affects rapidly dividing cells
- Stored in liver
  - Contains daily requirements for 3 – 6 months
- Serum decrease within 1 – 2 weeks of deficiency
- Serum folate = Folic acid intake over last several days
- Evaluate in conjunction with Vitamin B12
Vitamin B12

- Vitamin B12 = Cobalamin
- Daily requirement: 3 - 5 ug
- Stores in liver (50%), heart, and kidneys
  - Up to 5000 ug
  - Deficiency takes several years
Vitamin B12 continued

- Deficiency traps folate which leads to a functional deficiency of folate and blocks DNA synthesis
  - Serum Folate falsely elevated
- Common cause is absence of Intrinisic factor
  - IF is necessary for absorption
- Deficiency can result in neurological disease
Prealbumin

- Synthesized in liver
- Best indicator of protein-energy malnutrition
  - Half life 2 days
Reference Ranges

- Serum Folate: >3.5 ng/mL
- Vitamin B12: 180 – 914 pg/mL
- Prealbumin: 18.0 – 44.5 mg/dL
### Ordering Tests continued

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<tr>
<td>Serum Folate</td>
<td>Folic Acid</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>B12</td>
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<tr>
<td>Prealbumin</td>
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Conclusion

• There are many tests necessary to diagnose anemia
• CBC and Retic – Screening and general classification
• Iron Studies – Iron Deficiency Anemia and Anemia of Chronic Disease
• EPO – evaluated for many types of anemia
• Folate and B12 – Macrocytic Anemias
• Prealbumin – Nutritional status
QUESTIONS??
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