

**Sharpen Your Pediatric Laboratory Interpretation Skills:  
Pediatric Complete Blood Count (CBC), Differential, and Absolute Neutrophil Count (ANC)  
Louise D. Jakubik, PhD, RN-BC  
Pediatric Nursing Annual Conference 2010**

### Learning Objectives

At the completion of this program, the participants will be able to:

1. Identify the components of the CBC and Differential and their clinical implications.
2. Identify normal pediatric laboratory parameters for the CBC and differential as well as the clinical implications for deviations from normal.
3. Apply principles of pediatric CBC and differential interpretation to clinical practice scenarios.
4. Calculate the absolute neutrophil count (ANC).
5. Identify normal pediatric laboratory parameters for the ANC as well as the clinical implications for deviations from normal.

### Complete Blood Count (CBC) and Differential

#### Blood

- Plasma
  - Fluid Component: 90% water and 10% solutes (electrolytes and proteins)
- Formed Elements
  - Cellular component (WBC, RBC, Plt)

#### Hematopoiesis

- Definition: Formation of blood
- Hematopoietic Stem Cell: Origin of all blood cells
- Hematopoietic Organs:
  - Bone Marrow (myeloid tissue)
    - Location: long bones, ribs, sternum, vertebrae
    - Primary site of blood cell formation
    - T Lymphocytes are formed here and then migrate to the lymphatic system for maturation.
  - Lymphatic System
    - Lymph nodes, spleen, thymus, and tonsils
    - Young fetus: site of hematopoiesis together with the liver and bone marrow

Hgb  
WBC >-----< Plt  
Hct

Retic = \_\_\_\_\_

#### White Blood Cell (WBC, Leukocyte)

- Fight infection
- Attack foreign material
- 4,500 – 17,000 mm<sup>3</sup> (abbreviated as 4.5 – 17)
- Lifespan = hours – days
- Clinical implications for an Increased WBC
  - Infection, tissue necrosis, bone marrow malignancies, and inflammation
- Clinical implications for a Decreased WBC
  - Infections, conditions or medications that suppress or weaken the immune system or exhaust the bone marrow

#### WBC Differential

- Breaks down the WBC into their type (6 specific types)
- Each type is expressed as a percentage (%) of the total WBC count
- “Informative” component of the WBC
- Sum of the components of the WBC differential must add up to 100%

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**Neutrophils (31-57%)**

- First line of defense against infection
- Two types:
  - Bands or stabs (0) - immature
  - Segs (31% - 57%) – mature
- Clinical implications for increased neutrophils (neutrophilia)
  - Bacterial infection, some inflammatory conditions, tissue damage, and malignancies of the bone marrow (leukemia)
  - A rise in neutrophils in general is consistent with a **bacterial infection**
  - A rise in bands in particular is highly suggestive of **bacterial infection**
- Clinical implications for decreased neutrophils (neutropenia)
  - Some viral conditions, overwhelming infection that exhausts the bone marrow, cancer treatment drugs, certain antibiotics and psychotropic drugs, some hereditary disorders
  - Newborns with sepsis are at higher risk for developing neutropenia

**“Left Shift”**

- Increase in bands
- Many consider it to be an increase in the combined bands and segs
- Indicates a **bacterial infection**

**“Right Shift”**

- Technically, there is no such thing as a right shift.
- Practically, it indicates a rise in the monocytes and lymphocytes.
- Indicates a **viral infection**

**Monocytes (4-7%)**

- Second line of defense against infection
- Indicates a **viral infection**
- Clinical implications for increased monocytes (monocytosis)
  - Monocytic leukemia, ulcerative colitis, viral diseases such as mononucleosis and herpes zoster, parasitic diseases such as Rocky Mountain Spotted Fever
- Clinical implications for decreased monocytes (monopenia)
  - Some forms of leukemia, bone marrow failure or suppression

**Lymphocytes (35-61%)**

- Produced in the Lymphatic System
  - B Lymphocytes (B Cells): humoral immunity
  - T Lymphocytes (T cells): cell-mediated immunity
- Indicates a **viral infection**
- Clinical implications for increased lymphocytes (lymphocytosis)
  - viral infections (most common), bacterial or allergic conditions (less common)
- Clinical implications for decreased lymphocytes (lymphopenia)
  - Corticosteroid therapy, adrenocortical hyperfunction, stress, shock

**Eosinophils (2-4%)**

- Indicates **allergic disorders** and **parasitic infections**
- Clinical implications for increased eosinophils (eosinophilia)
  - Asthma, hay fever, drug reaction
- Clinical implications for decreased eosinophils (eosinopenia)
  - Corticosteroid therapy, adrenocortical hyperfunction, stress, shock

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**Basophils (0-1%)**

- Indicated systemic allergic reactions (inflammatory states)
- Responsible for histamine release
- Clinical implications for increased basophils (basophilia)
  - Chronic inflammatory and hypersensitivity reactions
- Clinical implications for decreased basophils (basopenia)
  - Corticosteroid therapy, adrenocortical hyperfunction, stress, shock

**Red Blood Cell (RBC, Erythrocyte)**

- Transports oxygenated Hgb to the tissues of the body
  - Contributes to maintenance of acid-base equilibrium
  - Lifespan = 120 days
  - Production is regulated by 2 things:
    - (1.) Tissue oxygenation
    - (2.) Renal production of erythropoietin
- \*Tissue hypoxia stimulates the kidneys to produce erythropoietin, which then stimulates the bone marrow to release RBC's.
- \*\*It is the ability of the RBC's to transport oxygen to the tissues of the body that regulates the production of RBC's NOT the number of RBC's circulating.**
- Clinical implications for increased hemoglobin (polycythemia)
    - Congenital heart disease, chronic hypoxia, high altitudes, polycythemia vera
  - Clinical implications for decreased hemoglobin
    - Renal disease, hematological conditions involving RBC destruction, iron deficiency, vitamin B12 deficiency, blood loss/hemorrhage, bone marrow suppression

**RBC Indices**

- Measures the size and Hgb content of the RBC
- Calculated based on mathematical formulas that reflect the relationships among the RBC, Hgb, and Hct
- Primarily used to differentiate between different types of anemia

**Mean Corpuscular Volume (MCV)**

- Indicates the average size of the RBC
- Three (3) Size Descriptions:
  - (1.) Normocytic: normal cell size (75-94); varies with age and gender
  - (2.) Macrocytic: large cell size (>94)
    - Clinical implications for increased MCV: folate or vitamin B12 deficiency, aplastic anemia, immune hemolytic anemia
  - (3.) Microcytic: small cell size (<75)
    - Clinical implications for decreased MCV: iron deficiency anemia, lead poisoning, thalassemia

**Mean Corpuscular Hemoglobin (MCH)**

- Measures average weight of Hgb per RBC {25-33 pg (picrograms)}
- Clinical implications for increased MCH: same as for MCV
- Clinical implications for decreased MCH: same as for MCV

**Mean Corpuscular Hemoglobin Concentration (MCHC)**

- Measures average concentration of Hgb per RBC
- Three (3) Hgb Concentration Descriptions:
  - (1.) Normochromic: normal Hgb concentration (33-36%); varies with age

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- (2.) Hyperchromic: increased concentration of Hgb per RBC (>36%)
  - Clinical implications for increased MCHC: hereditary spherocytosis
- (3.) Hypochromic: decreased concentration of Hgb per RBC (<33%)
  - Clinical implications for decreased MCHC: iron deficiency, thalassemia

**Red Cell Distribution Width (RDW)**

- Measures the uniformity of RBC size (11.5 – 14.5)
- Anisocytosis (increased RDW): indicated greater cell size variability
  - Clinical implications for increased RDW: iron deficiency anemia, folic acid deficiency anemia, and vitamin B12 deficiency anemia

**Reticulocyte (Retic Count)**

- Immature RBC (0.5% - 1.5%)
- Indicates active RBC production from the bone marrow
- An indirect measure of hematopoiesis
- Clinical implications for increased reticulocytes (reticulocytosis): acute anemia, chronic hemolytic anemia (sickle cell disease, hereditary spherocytosis)
- Clinical implications for decreased reticulocytes (reticulocytopenia): bone marrow failure syndrome, infectious bone marrow suppression, iron deficiency anemia, vitamin B12 deficiency anemia, folate deficiency anemia

**Hemoglobin (Hgb)**

- Component of the RBC that binds oxygen and delivers it to the tissues of the body (11.5 – 14.5 g/dl; varies based on age and gender)
- Types: dependent on stage in life and an abnormalities of the genes which regulate hemoglobin
- Composed of four (4) globin chains:
  - Hgb F (Fetal Hemoglobin): 2 alpha and 2 gamma chains
  - Hgb A (Adult Hemoglobin): 2 alpha and 2 beta chains
- Clinical implications for increased hemoglobin: congenital heart disease, chronic hypoxia, high altitudes, polycythemia vera, fluid loss (dehydration)
- Clinical implications for decreased hemoglobin (anemia): 4 causes
  - Decreased Production: aplastic anemia, renal disease, iron deficiency, bone marrow suppression
  - Increased Destruction: sickle cell disease, hereditary spherocytosis
  - Blood Loss: hemorrhage
  - Other: fluid volume overload

**Hematocrit (Hct)**

- Percentage of packed RBC to whole blood
- Expressed the ratio of cells to blood
- The relationship between Hct and Hgb is constant/fixed.
  - $Hct = 3 \times Hgb$
  - Hct rises and falls in the same direction and for the same clinical reasons as does Hgb.
- Clinical implications for increased hematocrit (same as for Hgb)
  - More cells
  - Less fluid
- Clinical implications for decreased hematocrit (same as for Hgb)
  - Fewer cells
  - More fluid

**Platelet (Plt)**

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- Cellular components needed to form a clot (150,000 – 450,000; abbreviated 150-450)
- Regulated by thrombopoietin; mechanism of action is largely unknown
- Clinical implications for increased platelets (thrombocytosis): acute blood loss, myeloproliferative disease, polycythemia vera
- Clinical implicates for decreased platelets (thrombocytopenia): 3 Causes
  - Decreased Production: leukemias, other primary bone marrow failure syndromes
  - Increased Destruction: idiopathic thrombocytopenia purpura (ITP), certain drugs
  - Abnormal Pooling: splenic sequestration, splenomegaly

### **Case Studies**

#### **Absolute Neutrophil Count (ANC)**

##### **Definition**

- Represent the actual number rather than the % of neutrophils.

##### **Clinical Implication**

- Indicates the degree of immune system functioning.

##### **Range**

- > 1000

##### **Neutropenia**

- ANC < 1000
  - 500 – 1000: indicates a moderate risk for infection
  - < 500: indicates a severe risk of life-threatening infection
- **Etiology**
  - Chemotherapy
  - Immunosuppression (Steroid Therapy)
  - Chronic Benign Neutropenia of Childhood
  - Syndromes affecting the immune system

##### **Calculation**

- Three calculation methods:  
Learn 1 and forget the other 2...
  - Method #1:  $(\text{Bands} + \text{Segs})\% \times \text{true WBC} = \text{ANC}$
  - Method #2:  $\{(\text{Bands} + \text{Segs}) \times \text{WBC}\} / 100 = \text{ANC}$
  - Method #3:  $(\text{Bands} + \text{Segs}) \times (\text{Abbreviated WBC} \times 10) = \text{ANC}$

### **Case Studies**

#### **Reference List**

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