Sharpen Your Pediatric Laboratory Interpretation Skills:
Pediatric Complete Blood Count (CBC), Differential, and Absolute Neutrophil Count (ANC)
Louise Jakubik, PhD, RN-BC, CSP
***Pediatric Nursing* Annual Conference 2018**

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. Identify normal pediatric laboratory parameters for the ANC as well as the clinical implications for deviations from normal.
5. Calculate the absolute neutrophil count (ANC).

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
- Hematopoetic Stem Cell: Origin of all blood cells
- Hematopoetic 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^3 (abbreviated 4.5 – 17)
  - Higher in neonates
  - High end normal peaks at 2 years of age at 17,000 mm3, falls during child hood, then reaches adult normal range of 4,500-11,000 mm3
- 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

Sharpen Your Pediatric Laboratory Interpretation Skills:
Pediatric Complete Blood Count (CBC), Differential, and Absolute Neutrophil Count (ANC)
Louise Jakubik, PhD, RN-BC, CSP
***Pediatric Nursing* Annual Conference 2018**

WBC Differential ("diff")

- 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%

Neutrophils (31-57%)

- First line of defense against infection
- Two types:
  - Bands or stabs (0) - immature
  - Segs (31% - 57%) – mature
- Clinical implications for <u>increased neutrophils</u> (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 **<u>bacterial Infection</u>**
  - A rise in bands in particular is **highly suggestive** of **<u>bacterial infection</u>**
- Clinical implications for <u>decreased neutrophils</u> (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 **<u>bacterial infection</u>**
- Sometimes expressed as an I:T ratio ≥ 0.2
  - I:T ratio calculation = Immature Neutrophils (Bands)/ Total Neutrophils (Bands + Segs)

"Right Shift"

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

Monocytes (4-7%)

- Second line of defense against infection
- Indicates chronic viral or bacterial infection
- Generally consistent with a **<u>viral infection</u>**
- Clinical implications for <u>increased monocytes</u> (monocytosis)
  - Monocytic leukemia, ulcerative colitis, viral diseases such as mononucleosis and herpes zoster, parasitic diseases such as Rocky Mountain Spotted Fever
- Clinical implications for <u>decreased monocytes</u> (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 acute viral or chronic bacterial infection
- Generally consistent with a **<u>viral infection</u>**
- Clinical implications for <u>increased lymphocytes</u> (lymphocytosis)
  - viral infections (most common), bacterial or allergic conditions (less common)

- Clinical implications for <u>decreased lymphocytes</u> (lymphopenia)
    - Corticosteroid therapy, adrenocortical hyperfunction, stress, shock

Eosinophils (2-4%)

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

Basophils (0-1%)

- Indicates <u>systemic allergic reactions</u> (inflammatory states)
- Responsible for histamine release
- Clinical implications for <u>increased basophils</u> (basophilia)
    - Chronic inflammatory and hypersensitivity reactions
- Clinical implications for <u>decreased basophils</u> (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 <u>increased hemoglobin</u> (polycythemia)
    - Congenital heart disease, chronic hypoxia, high altitudes, polycythemia vera
- Clinical implications for <u>decreased hemoglobin</u>
    - Renal disease, hematological conditions involving RBC destruction, iron deficiency, vitamin B12 deficiency, blood loss/hemorrhage, bone marrow suppression

RBC Indices

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

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 <u>increased MCV</u>: folate or vitamin B12 deficiency, aplastic anemia, immune hemolytic anemia

  (3.) Microcytic: small cell size (<75)
    - Clinical implications for <u>decreased MCV</u>: 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
  - (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 any 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 X Hgb
  - Hct rises and falls in the same direction and for the same clinical reasons as does Hgb.
- Clinical implications for <u>increased hematocrit</u> (same as for Hgb)
  - More cells
  - Less fluid
- Clinical implications for <u>decreased hematocrit</u> (same as for Hgb)
  - Fewer cells
  - More fluid

Platelet (Plt)

- 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 <u>increased platelets</u> (thrombocytosis): acute blood loss, myeloproliferative disease, polycythemia vera
- Clinical implicates for <u>decreased</u> 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

Case Study #1

Michael's CBC with differential is the following:
WBC 32 Hb 11 Hct 31 Plt 360 Bands 15 Segs 60 Mono 7 Lymphs 15 Eos 3

1. What values are elevated?

2. Does Michael's CBC represent a "left" or a "right" shift?

3. What is the probable cause of Michael's infection?

Case Study #2

Jamie's CBC is the following:
WBC 10 Hb 7 Hct 21 Plt 390 Retic 13

1. What is abnormal about Jamie's CBC?

2. What does that abnormality indicate?

Case Study #3

Sarah's CBC is the following:
WBC 14 Hb 6 Hct 19 Plt 250 Retic 0.5 MCV 60

1. What is abnormal?

2. What does the abnormality indicate?

3. What condition might you suspect?

Sharpen Your Pediatric Laboratory Interpretation Skills:
Pediatric Complete Blood Count (CBC), Differential, and Absolute Neutrophil Count (ANC)
Louise Jakubik, PhD, RN-BC, CSP
***Pediatric Nursing* Annual Conference 2018**

Absolute Neutrophil Count (ANC)

Definition

- Represent the actual number rather than the % of neutrophils
- Indicates the degree of immune system functioning

Range

- Normal ANC > 2500
- Neutropenia = ANC <1000
    - ANC 500-1000: moderate risk of infection
    - ANC <500: severe risk of life-threatening infection

Nursing Implications

- Be aware that signs of infection may be lessened such as edema and redness
- Decrease contact with pathogens
    - Hospitalized child = Private room; cohort with roommate without an infection
    - Outpatient = Avoid large crowds (e.g. movie theatre, crowded grocery store, etc.) and people who are ill
- Initiate protective isolation if ANC < 500
- Proper hand washing
- Antibiotics as ordered

Etiology

- Immunosupression (e.g. chemotherapy, steroids, etc.)
- Chronic Benign Neutropenia of Childhood
- Syndromes affecting the immune system

Calculation

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

ANC Tip!

- Look at the WBC to determine whether the ANC will be normal, high, or low!
- Normal WBC Count Range =
    - 4,500-17,000 mm^3
    - Abbreviated 4.5 - 17
- Normal WBC = Normal ANC
- Low WBC = Low ANC (neutropenia)
- High WBC = Normal/High ANC (infection)

Case Study

Suzie's CBC is the following: WBC 3 Hb 9 Hct 28 Plt 180 Bands 0 Segs 15

1. What is her ANC ?

2. What does her ANC indicate?

Sharpen Your Pediatric Laboratory Interpretation Skills:
Pediatric Complete Blood Count (CBC), Differential, and Absolute Neutrophil Count (ANC)
Louise Jakubik, PhD, RN-BC, CSP
***Pediatric Nursing* Annual Conference 2018**

Reference List

Corbett, J. V. (2000). *Laboratory Tests and Diagnostic Procedures with Nursing Diagnosis (5th ed.)* Upper Saddle River, New Jersey: Prentice Hall Health.

Guyton, A. C. & Hall, J. E. (2000). *Textbook of Medical Physiology (3rd ed.).* Philadelphia: W. B. Saunders Company.

Hazinski, M. F. (1988). Understanding fluid balance in the seriously ill child. *Pediatric Nursing*, *14*, 231-236.

Hazinski, M.F. (2013). Nursing Care of the Critically Ill Child (3rd ed.) St Louis: Mosby.

Jakubik, L. (2011). Pediatric Laboratory Interpretation: A Guide for the Pediatric Nurse (1st Ed.). Philadelphia: Nurse Builders. www.nursebuilders.net

Jakubik, L. D., Cockerham, J., Altmann, A., & Grossman, M. B. (2003). The ABCs of pediatric laboratory interpretation: Understanding the CBC with differential and LFTs. *Pediatric Nursing,* 29(2), 97-103.

Jakubik, L. D., Deatrick, J. A., & Woodring, B. C. (2002). Pediatric complete blood count, reticulocyte count, WBC differential, and absolute neutrophil count. In, *Pediatrics Mastering New Clinical Specialties: A Competency Based Approach to Cross-training and Skill Enhancement* (module 8: pp. 1-38). Cypress, CA: Medcom Trainex.

Jakubik, L. D. & Thompson, M. (2000). Care of the child with sickle cell disease: Acute complications. *Pediatric Nursing*, 26(4), 373-379.

Kee, J. L. (1999). *Laboratory and Diagnostic Test with Nursing Implications (5th ed.).* Stamford, Connecticut: Appleton and Lange.

Lilleyman, J., Hann, I., & Blanchette, V. (1999). *Pediatric Hematology (2nd ed.). London:* Churchill Livingstone.

Malarkey, L.M. & McMorrow, M. E. (Eds.) (2000). *Nurse's Manual of Laboratory Tests and Diagnostic Procedures* (2nd ed.). Philadelphia: W. B. Saunders Company.

Muscari, M. E. (2004). Lippincott's Review Series: Pediatric Nursing (4th ed.). Philadelphia: Lippincott Williams & Wilkins.

Nathan, D. G. & Oski, F. A. (1999). *Hematology of Infancy and Childhood (5th ed.)* Philadelphia: W. B. Saunders Company.