



Understanding the CBC

What is Hematology?

Hematology is the science of blood and blood-forming tissues. Blood is made up of plasma and blood cells. Blood formation (hematopoiesis) is a continuous process that occurs in the bone marrow. Within the bone marrow there is a pluripotent stem cell, *the Mother Cell*, the originator of all types of blood cells. The stem cell produces blood cells that exit the bone marrow and circulate in the blood system. Red cells circulate about four months, platelets last an average of ten days, and white cells range from only hours to a week or so. Stem cells that are found outside the bone marrow are called “peripheral stem cells” and are collected and frozen for stem cell transplants.

What is a CBC?

The CBC- the complete blood count, or *the counts*- is a lab test that will be ordered frequently on your child. This test determines the number, type, percentage, concentration and quality of the various types of blood cells that make up the blood. This test can be completed on blood that is collected by a finger stick, a lab draw from a central vein access and/or a *straight draw* from a peripheral vein, (usually from an arm, hand or foot).

The CBC is commonly performed on an automated analyzer. However when abnormalities are noted in the blood, parts of the test can be completed *manually*. That is when the blood sample is viewed under the microscope. Some institutions commonly perform an extensively complete CBC and others may perform just specific aspects of the CBC.

When evaluating a CBC it is important to remember that normal ranges can vary depending on many factors- the individual's age, their hydration status, and even can change between different laboratories. Compare your child's results with what is considered the normal range for that institution. When viewing your child's printed lab results, the normal range, or *reference range*, is usually printed alongside your child's results.

There are three different types of blood cells- erythrocytes, (red blood cells/ RBCs); leukocytes, (white blood cells/ WBCs) and thrombocytes (platelets).

Erythrocytes (RBCs)

The primary function of erythrocytes is to carry oxygen from the lungs to the body and bring carbon dioxide from the body to the lungs. RBCs usually live for approximately 120 days. The liver, spleen and bone marrow cleanse them from the blood. In response to a low amount of circulating RBCs, the kidney releases a hormone that stimulates the bone marrow to make more RBCs. RBC is measured in millions of cells per microliter μL or cubic millimeter mm^3 .

A significantly higher amount of RBCs than normal is called *polycythemia*. There are various causes of polycythemia in children, including congenital heart defects. A child undergoing treatment for neuroblastoma is more likely to experience *anemia*, a decrease in RBCs, as a side effect of chemotherapy and radiation. (Anemia can also be defined as a decrease in the hemoglobin.)

Reticulocyte Count

When RBCs are released from the bone marrow, they are slightly immature. These immature cells are called reticulocytes. A reticulocyte count, or *retic count* measures the number of reticulocytes circulating in the blood. A low retic count can be seen in bone marrow failure. A high retic count can mean that the bone marrow is responding to the need for an increase in the production of RBCs. This can be seen in cases of anemia and blood loss. Retic counts are closely monitored in leukemia.

Hemoglobin (Hgb)

Hemoglobin is a combination of protein and iron within the red blood cell. The hemoglobin is the part of the RBC that carries oxygen and is measured in grams per deciliter (g/dL). Anemia is a low hemoglobin level. It is the decrease in the oxygen- carrying capacity of the blood that can make your child tired when your child is anemic. Elevated hemoglobin can indicate dehydration or polycythemia. Hemoglobin is the first *H* in an *H and H*.

Hematocrit (Hct)

Hematocrit is the second *H* in an *H and H*. The hematocrit or *crit* measures the percent by volume of blood that is comprised of RBCs. The hematocrit may be determined by spinning a blood sample in a centrifuge. That is why you may hear the phrase, *spinning a crit*. A low hematocrit can indicate blood loss, anemia, or bone marrow suppression, and dehydration can cause a “false” elevation in the hematocrit. (See “Blood Transfusions”)

Erythrocyte Indices

When the hemoglobin is low, it is important to look at the erythrocyte indices. Each of the indices evaluates a different aspect of the RBC. These indices are considered in relation to your child’s diagnosis and current treatment.

Mean corpuscular volume (MCV)

The MVC measure the average size of the RBC. Small RBCs can be seen in anemia, lead poisoning, genetic diseases and cancers. Large RBCs are seen in other types of anemia and chronic liver disease.

Mean corpuscular hemoglobin (MCH)

The MCH measures the weight of hemoglobin present in an RBC. This level can be low or high with different types of anemia.

Mean corpuscular hemoglobin concentration (MCHC)

The MCHC measures the proportion of hemoglobin in the RBC. It can be decreased with anemia and is rarely high.

Nucleated red blood cells (NRBC)

NRBCs are abnormal in peripheral blood except in newborns. The presence of NRBC in a CBC can indicate bone marrow recovery from anemia after chemotherapy.

Leukocytes (WBCs)

Leukocytes help to protect the body from infection by a process called phagocytosis. This is when the WBC surrounds and destroys a foreign cell. WBCs also produce, transport and distribute antibodies. WBCs usually live for 13 to 20 days and are destroyed by the lymphatic system.

There are 5 different types of WBCs. Neutrophils, eosinophils and basophils are called granulocyte white blood cells. Granulocyte WBCs have granules when they are stained and viewed under a microscope. Lymphocytes and monocytes do not have granules and are called agranulocytes.

WBCs are usually evaluated in two different ways. The *Absolute number* is the total number of that type of WBC in a microliter (μL) which is equal to a cubic millimeter (mm^3) of blood. The *differential, the diff*, reports the percentage of each of the 5 white blood cells, with the percentages adding up to 100%. Both aspects of the white blood cells are considered when making a WBC assessment.

The Total WBCs can be elevated (leukocytosis) with infection, trauma, leukemia and post-operative period. This level can be low (leukopenia) due to immune disorders, chemotherapy, radiation, and cancer. WBC levels can be affected by the body's own stimulating factors or those that are commonly injected subcutaneously when the child's WBC counts drop after chemotherapy.

Neutrophils

Neutrophils kill bacteria. You may hear neutrophils called *segs*. This is because mature neutrophils have a segmented appearing nucleus. An elevated neutrophil (neutrophilia) count usually represents bacterial infection and/or inflammation. An Absolute low neutrophil count (neutropenia) can represent bone marrow suppression from chemotherapy and/or radiation, a severe infection, or a process known as sepsis. (See Chapter 3 “**Surviving Neutropenia**”)

Immature neutrophils do not have a segmented nucleus; they have a band-shaped nucleus. So when young neutrophils are released from the bone marrow, they are called *bands*. The phrase *a shift to the left* is used when the band level has increased. It is a holdover phrase from the days when lab reports were handwritten and bands were written first on the left hand side of the report.

An important factor used in monitoring your child's ability to fight infection is called the ANC (Absolute Neutrophil Count). The ANC is not measured directly. It is determined by multiplying the WBC count by the percent of neutrophils in the differential WBC count. The percent of neutrophils consists of the segmented neutrophils plus the bands. The normal range for the ANC is 1.5 to 8.0 ($1,500$ to $8,000/\text{mm}^3$). When the ANC is under 500 (or 0.5) your child is at risk for serious infection and this is why fevers are treated with IV antibiotics in the hospital.

Sample calculation of the ANC

WBC count: 6,000 cells/ mm^3 of blood (or 6.0)
Segs: 31% of the WBCs
Bands: 4% of the WBCs
Neutrophils: segs + bands = 35% of the WBCs
ANC: $35\% \times 6,000 = 2100/\text{mm}^3$ or by convention = 2.1
Normal range: 1.5 to 8.0 ($1,500$ to $8,000/\text{mm}^3$)
Interpretation: Normal

Eosinophils

Eosinophils are commonly associated with hypersensitivity reactions or parasitic infections. A high eosinophil count would be expected in an allergic reaction. A low eosinophil count can occur when the child is receiving corticosteroids.

Basophils

Basophils have a role in the body's immune response, by releasing histamine and heparin. Their small numbers increase during the healing process or when there is an alteration in bone marrow

function. A drop in the basophil level may occur with corticosteroid use, with an allergic reaction, or during an acute infection.

Lymphocytes

Lymphocytes are active in immunity. They are produced in the bone marrow but mature in lymphoid tissue. The total lymphocyte count represents the total number of T and B-lymphocytes. Simply put, T cells (helper cells, killer cells, cytotoxic cells, regulator cells and memory cells) are the master immune cells and they tell the B cells to make antibodies. Lymphocytes increase with viral infections, tuberculosis, and leukemia and decrease with corticosteroids and other immunosuppressive medications.

Monocytes

Monocytes are the largest cells in the blood. They are phagocytic, ingesting debris from cells when there is infection or inflammation. They have been likened to the Pacman video game. Some monocytes enter tissue where they enlarge and mature into macrophages. Monocytes typically increase after several days of infection or inflammation.

Thrombocytes (Platelets)

Platelets are actually cell fragments, not true cells. They are made in the bone marrow and circulate in the blood for approximately 10 days, and are measured by thousands per microliter μL . Platelets are essential to blood clotting (coagulation). When blood comes into contact with anything other than the smooth lining of the blood vessels, platelets stick together to form a plug and release chemicals that further assist clot formation.

Thrombocytopenia, a platelet count below 50,000, can occur with bone marrow suppression from chemotherapy and/or radiation, leukemia, malignancies of the bone and autoimmune disorders. Medications that increase the production of white blood cells in the bone marrow, (i.e. G-CSF), may decrease the bone marrow's production of platelets.

Thrombocytosis, an increase in the platelet count, can occur with dehydration, spleen dysfunction, or as a response to injury or inflammation.

CBC evaluation

When your child's treatment team evaluates a CBC, they do so in conjunction with understanding your child's present symptoms, physical exam, current treatment, treatment history, and any other factors that are pertinent to your individual child. It can be helpful to keep track of your child's counts yourself along with normal ranges and units for comparing results (see Chapter 10 "**Keeping Records**").

Sources:

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Ed Uthman, MD, American Board of Pathology http://web2.iadfw.net/uthman/blood_cells.html

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