ASCP PATIENT CHAMPIONS

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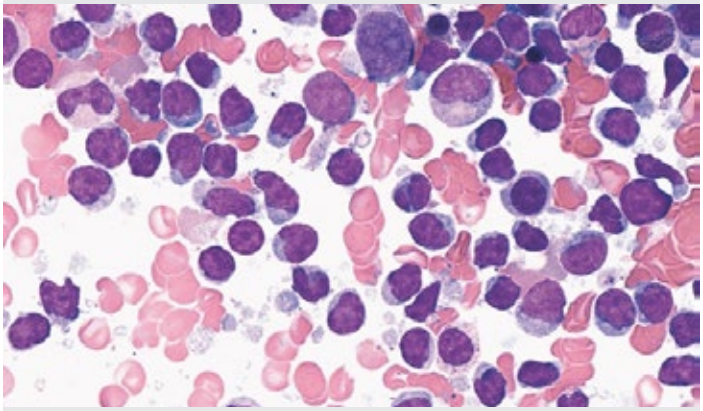
LAB TESTS RELATED TO LEUKEMIA

*Leukemia can affect people of all genders. In this material, the terms "male" and "man" are used to refer to people assigned male at birth. The terms "female" and "woman" are used to refer to people assigned female at birth.

WHAT IS LEUKEMIA?

Leukemia is a cancer that affects the blood. A primitive blood cell develops into a leukemic cell in the bone marrow then replicates itself faster than is normal, crowding out healthy blood cells. Those leukemia cells may continue to replicate and eventually leave the bone marrow, spreading into the blood (leukemia) or as solid masses in other parts of the body (lymphoma). Leukemia commonly hinders the body's immune response because the cancerous cells do not function normally and inhibit the function of normal cells. Leukemia is acute if it develops rapidly in immature cells, while it is chronic if it develops more slowly in partly mature cells. Leukemia can also be divided into lymphocytic leukemia and myeloid leukemia, depending on if the cells affected would have been lymphocytes or myeloid cells. The four most common types of leukemia are acute myeloid, chronic myeloid, acute lymphocytic, and chronic lymphocytic. Two rare forms of leukemia can arise from the primitive cells that form red blood cells (erythroid leukemia) or platelets (megakaryocytic leukemia).

UNDER THE MICROSCOPE



Picture Legend: Chronic lymphocytic leukemia is characterized by an abundance of immature lymphocytes (a type of white blood cell) arising in the bone marrow and found in abundance in peripheral blood. Normally, only one white blood cell is seen for every hundred red blood cells. Here, many more white blood cells are present than would be in a healthy blood sample.

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LABORATORY TESTS RELATED TO LEUKEMIA

There are numerous laboratory tests used every day in patients with or suspected to have leukemia. Some of those tests, like a complete blood count (CBC) test, offer an overview of the composition of a sample of blood and are useful in determining if there are any abnormalities. If the sample has higher-than-usual white blood cell counts and lower-than-usual red blood cell counts, lymphoid or myeloid leukemia may be suspected. If leukemia is suspected, the physician may order additional tests to confirm the diagnosis. One common test is a blood smear, in which a sample of blood is analyzed through a microscope for quantitative evidence of leukemia as well as abnormalities in the size and shape of blood cells. More specialized tests may also be used to determine specific information about the cancer, like if and where it has spread throughout the body and if there are chromosomal abnormalities in the cancerous cells. This information is used by physicians to determine the most effective treatment for each specific case of leukemia. Some of the most common lab tests are described here, but there are many other tests that are not covered.

LABORATORY TESTS FOR IDENTIFYING LEUKEMIA*:

**Please note that reference ranges are set by individual laboratories or their specific populations and vary accordingly. Therefore, discussion of your specific testing results with your healthcare provider is recommended.*

Bone Marrow Biopsy and Aspiration: This test involves removing a small sample of bone (biopsy) and a small amount of liquid bone marrow (aspiration) for analysis under a microscope. This procedure is performed in patients with high suspicion of bone marrow abnormalities, either from specific symptoms or a complete blood count result (see below). This test is important because it identifies abnormalities in the ratio of blood cells present and the size and shape of those blood cells. This test can determine the stage and severity of leukemia present in the samples.

Complete Blood Count (CBC): This series of laboratory tests is usually the first administered to a potential leukemia patient and may be repeated throughout treatment. It measures the prevalence of red blood cells, white blood cells, and platelets in a unit of blood. The results of this test are compared against the reference ranges of healthy individuals to identify any abnormalities. Common results of a patient with leukemia are higher-than-expected white blood cell counts and lower-than-expected red blood cell counts, but other diseases and conditions could cause this same result. A complete blood count is a ubiquitous and useful first test in identifying irregularities in a patient's blood, but additional tests will be necessary to determine if leukemia is causing those irregularities.

Peripheral Blood Smear: This test generally follows a CBC when abnormalities were identified. This test involves looking at a sample of blood under a microscope to calculate the number of each type of blood cell present and determine if the cells are immature or abnormal in size and shape. Depending on the results of the test, leukemia may be suspected as the cause of the abnormalities.

TYPICAL REFERENCE RANGES FOR MEN*:

Hematocrit	Plasma in Red Blood Cells	38.3-48.6%
Hemoglobin	Oxygen-Carrying Protein	13.2-16.6 grams/dL
Platelet Count	Blood Clotting	135-317 x 10^3/uL
Red Blood Cell Count	Carry Oxygen	Between 4.35-5.65 x 10^6/uL
White Blood Cell Count	Fight Infections	3400-9600 cells/uL

TYPICAL REFERENCE RANGES FOR WOMEN*:

Hematocrit	Plasma in Red Blood Cells	35.5-44.9%
Hemoglobin	Oxygen-Carrying Protein	11.6-15 grams/dL
Platelet Count	Blood Clotting	157-371 x 10^3/uL
Red Blood Cell Count	Carry Oxygen	Between 3.92-5.13 x 10^6/uL
White Blood Cell Count	Fight Infections	3400-9600 cells/uL

Peripheral Blood Cell Differential: This test measures the prevalence of different types of white blood cells. It may be ordered as a part of a CBC, or as a follow-up test to the CBC to explain any abnormalities which may have been identified. The test quantifies the prevalence of each of the five types of white blood cells: monocytes, lymphocytes, neutrophils, basophils, and eosinophils. This test can help a physician determine the type and stage of leukemia present, as well as the strength of the body's immune response.

WHITE BLOOD CELL	TYPICAL REFERENCE RANGE*
NEUTROPHILS	55%-70%
BAND NEUTROPHILS	0%-3%
LYMPHOCYTES	20%-40%
MONOCYTES	2%-8%
EOSINOPHILS	1%-4%
BASOPHILS	0.5%-1%

**Values taken from the Leukemia and Lymphoma Society*

ADDITIONAL LABORATORY TESTS RELATED TO CLASSIFYING AND TREATING LEUKEMIA

Molecular Tests: Analyzing chromosomes and genetic sequence is important in diagnosing and treating certain types of leukemia, as chromosomal abnormalities can be the cause of the leukemia.

Cytogenetic Analysis (Karyotyping): This test looks at the chromosomes in cells taken from bone marrow to determine if there are genetic changes associated with leukemia. Cytogenetic analysis can lead to a more accurate diagnosis and help determine the aggressiveness of the cancer if it has a chromosomal origin. Some specific cytogenetic anomalies indicate specific treatments that patients may undergo.

Fluorescent in situ Hybridization (FISH): This test involves taking a sample of leukemic cells and introducing a fluorescent dye which is designed to adhere to some genetic DNA abnormalities. The fluorescent dye of two different colors binds to specific regions of a chromosome that should either be naturally together or separated. When an abnormality is present, the markers are in the opposite orientation. It is commonly used in diagnosing chronic myeloid leukemia (CML), as it can identify the genetic abnormality BCR-ABL in which a part of chromosome 22 and chromosome 9 exchanged genetic material. Identifying BCR-ABL can confirm a chronic myeloid leukemia diagnosis.

Polymerase Chain Reaction (PCR): This test involves replicating a small sample of genetic material in the laboratory. This process allows for genetic abnormalities to be identified at a much lower threshold and can be used to identify the BCR-ABL change when diagnosing chronic myeloid leukemia (CML).

Genetic Sequencing: This test involves reading a specific portion of the human genome from a patient with leukemia to detect specific changes that may indicate or confirm a diagnosis or indicate a specific type of treatment.

Minimal Residual Disease Testing: This is a general concept which means to look for the smallest amount of detectable leukemia possible with a very sensitive test. These tests may include PCR or sequencing.

IMMUNOPHENOTYPING

Flow Cytometry: This test involves introducing a sample of blood or bone marrow to specifically-designed antibodies (bound to fluorescent markers) and then analyzing them with a laser and computer. The antibodies used in a flow cytometry test are designed to strongly bind to certain proteins which are present in cancerous cells. The samples are then analyzed under a laser (which excites the fluorescent markers) to see if the antibodies are bound. This test can be used to diagnose and monitor leukemia.

Immunohistochemistry: This test involves introducing a tissue sample (such as bone marrow or lymph nodes) to specifically-designed antibodies and then analyzing them with a microscope. The antibodies used in an immunohistochemistry test are designed to bind to certain proteins which are present in cancerous cells. The samples are then analyzed under a microscope to see if the antibodies are bound and are detected by colored dyes attached to the antibodies. This test can be used to diagnose and monitor leukemia.

Spinal Tap (Lumbar Puncture): This test involves removing cerebrospinal fluid (CSF) from inside the spinal cord and analyzing it for signs of leukemia. If there is evidence that the leukemia has spread from the bone marrow to the cerebrospinal fluid, additional treatment may be ordered.

MEET DEEDEE

Deedee watched her mother and brother get diagnosed with chronic lymphocytic leukemia (CLL), then a decade later received the same diagnosis herself. After reading her mother's blood work every month during her treatment, Deedee knew what to look for in her own blood tests. Chronic lymphocytic leukemia can be asymptomatic for years, but Deedee's genetic predisposition to CLL and her familiarity with lab testing led her to seek out expert advice very early.

Deedee was able to get diagnosed with CLL early in the cancer's progression and now receives a complete blood count every three months to monitor its development. She credits the laboratory with allowing her to continue living the life she loves.

"Everything surrounding my sicknesses, my cancer, my life going forward, is dependent on lab work."

To learn more and to watch a video about Deedee, go to **www.ascp.org/patients**

QUESTIONS TO ASK YOUR DOCTOR

- What is the course of action based on my lab results?
- How will the lab test results impact my treatment plan?
- What are all my treatment options?
- Why do you recommend this particular treatment option?
- How do we know the procedure was successful/what lab tests and which results indicate a successful procedure?
- What are the markers we are monitoring? What are the levels we are hoping for? What happens if the markers are higher or lower than we would like to see?
- What are the follow-up tests and what are we looking for?