

LESSON

2-10

Abnormalities in Peripheral Blood Cell Morphology

LESSON OBJECTIVES

After studying this lesson, the student will:

- State the importance of differentiating between normal and abnormal blood cells on a peripheral blood smear.
- List two conditions in which anisocytosis is found.
- List two conditions in which poikilocytosis is found.
- List two conditions in which hypochromic red blood cells can be found.
- Discuss the relationship of the red blood cell indices to red blood cell morphology.
- Discuss the significance of RBC inclusions.
- List two causes of leukopenia.
- List two causes of leukocytosis.
- Discuss neutrophilia and a shift to the left.
- Discuss the characteristics of leukemias.
- List conditions in which abnormal thrombocytes can be found.
- List safety precautions to be observed when examining a blood smear.
- Discuss the importance of quality assessment when examining blood smears that contain abnormal cells.
- Define the glossary terms.

GLOSSARY

basophilia / abnormal increase in the number of basophils in the blood

basophilic stippling / remnants of RNA and other basophilic nuclear material remaining inside the erythrocyte after the nucleus is lost from the cell and which appear as small purple granules in red blood cells stained with Wright's stain

blast cell / an immature blood cell normally found only in the bone marrow

codocyte / target cell

crenated cell / a shrunken red blood cell with scalloped or toothed margins

drepanocyte / sickle cell

elliptocyte / elongated, cigar-shaped red blood cell

eosinophilia / abnormal increase in the number of eosinophils in the blood

femtoliter (fL) / a unit of volume; 10^{-15} L

folic acid / a member of the B vitamin complex

- Howell-Jolly body** / nuclear remnant remaining in red blood cells after the nucleus is lost, commonly seen in pernicious anemia and hemolytic anemias
- keratocyte** / a red blood cell deformed by mechanical trauma
- leukemia** / a chronic or acute disease involving unrestrained growth of leukocytes
- mean cell hemoglobin (MCH)** / mean corpuscular hemoglobin; average red blood cell hemoglobin expressed in picograms (pg)
- mean cell hemoglobin concentration (MCHC)** / mean corpuscular hemoglobin concentration; comparison of the weight of hemoglobin in a red blood cell to the size of the red blood cell, expressed in percentage or g/dL
- mean cell volume (MCV)** / mean corpuscular volume; average red blood cell volume in a blood sample, expressed in femtoliters (fL) or cubic microns (μ^3)
- neutrophilia** / abnormal increase in the number of neutrophils in the blood
- nucleated red blood cell (NRBC)** / a red blood cell that has not yet lost its nucleus
- picogram (pg)** / micromicrogram; 1×10^{-12} g
- red blood cell indices** / calculated values that compare the size and hemoglobin content of red blood cells in a blood sample to reference values; erythrocyte indices
- schizocyte** / a fragmented red blood cell; formerly schistocyte
- shift to the left** / the appearance of an increased number of immature neutrophil forms in the peripheral blood
- sickle cell** / crescent- or sickle-shaped red cell; drepanocyte
- sickle cell anemia** / inherited blood disorder in which red blood cells can form a sickle shape due to the presence of hemoglobin S
- stomatocyte** / red blood cell with an elongated, mouth-shaped central area of pallor
- target cell** / abnormal red blood cell with target appearance; codocyte
- thalassemia** / an inherited condition in which abnormal hemoglobin is produced, resulting in anemia
- vitamin B₁₂** / a vitamin essential to the proper maturation of blood and other cells in the body

INTRODUCTION

The information gained from a complete blood count (CBC) with a differential count can be very valuable to the physician in making or confirming a diagnosis. Several conditions can be indicated by the presence of abnormal red or white blood cells observed while performing a differential count.

Occasional abnormal red and/or white blood cells can be observed on a peripheral blood smear that is considered to be normal. The finding might be as simple as finding a few hypochromic red cells in the smear of a patient with mild iron deficiency anemia or observing a small number of atypical lymphocytes associated with a viral infection. However, there are also times when examination of a smear expected to be normal yields unexpected results, such as the observation of immature white blood cells. These abnormal cells could be few in number and might only be recognized by an experienced technologist, or they could be numerous but difficult to classify. Becoming proficient in identification of abnormal

cells comes only after much practice in the identification of normal cells.

Some conditions and diseases present very characteristic cellular changes in blood cells that can be observed on a Wright's-stained smear. Conditions such as iron deficiency anemia, folic acid deficiency, vitamin B₁₂ deficiency, and sickle cell anemia produce characteristic changes in the red cell morphology. Abnormalities in the white blood cell count, percentages of white blood cells, and/or white blood cell morphology can result from conditions such as viral or bacterial infections, hematological diseases, allergic reactions, stress, or recent exercise. Certain conditions also cause abnormalities in platelet numbers and/or morphology.

Evaluation of red and white blood cell morphology is an important part of the white blood cell differential count. The information can aid in diagnosis or treatment of disease. Correct identification of cells and accurate evaluation of cell morphology requires much knowledge and practice. The technologist must be proficient in identifying normal cells before studying abnormal

morphology. The student should successfully complete Lessons 2-8 and 2-9 before attempting this lesson.

Safety Precautions



Standard Precautions must be observed during the preparation and staining of blood smears. Chemical and physical hazards are present when using blood stains, handling glass slides, and operating electrical equipment. Appropriate personal protective equipment (PPE) must be worn. The methanol used in the staining process is toxic; splashes onto the skin or into the eyes must be avoided. Glass slides should be handled carefully to avoid cuts. The microscope cord and plug should be inspected before the microscope is connected to power.

Quality Assessment



All personnel who perform white blood cell differential counts and evaluate white and red blood cell and platelet morphology should follow the written procedure of the facility. This will describe the area of the slide to be examined, the pattern of counting, and a standardized method of grading any abnormal morphology that is observed. The quality of the smear, the staining technique, and the method of examining the smear influence the quality of the results.

A smear can contain abnormal cells, even though the patient seems normal, or healthy. Technologists performing differential counts must be experienced and conscientious. A more experienced worker, laboratory supervisor, or pathologist must be consulted if there are questions regarding cell identification.

ABNORMAL ERYTHROCYTE MORPHOLOGY

Disorders that affect the red blood cells can cause *poikilocytosis*, variations in shape, or *anisocytosis*, variations in size. Increase (erythrocytosis) or decrease (anemia) of the red blood cell numbers from the normal reference range and changes in the hemoglobin content of red blood cells can also occur (Table 2-13).

Anisocytosis

Red blood cells of normal size, 6 to 8 μm in diameter, are said to be *normocytic*. Red blood cells that are smaller than 6 μm are *microcytic* (Figure 2-62). Patients with conditions such as iron deficiency anemia and inherited conditions such as thalassemia have microcytic red blood cells. Thalassemias are caused by defects in the synthesis of the globin portion of the hemoglobin molecule. Iron deficiency anemia can be due to conditions such as inadequate intake of dietary iron, an increased iron demand in pregnancy, or chronic blood loss.

Red blood cells with a diameter greater than 8 μm are *macrocytes*, also called *megalocytes*. Macrocytes are produced in deficiencies of vitamin B₁₂ or folic acid (folate) and in liver disease. Deficiency of vitamin B₁₂ or folic acid prevents proper maturation

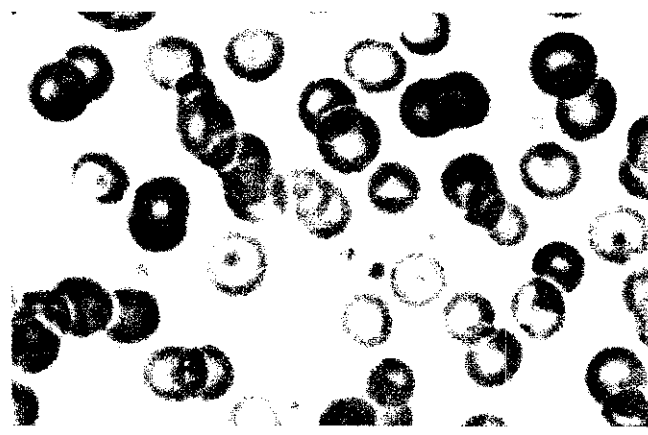


FIGURE 2-62 Abnormal RBC morphology showing target cells and hypochromic microcytes

of blood cells in the bone marrow, causing the cells to remain larger than normal. Vitamin B₁₂ deficiency was formerly known as pernicious anemia because it was a fatal disease until its cause and treatment were discovered in the mid-1950s.

Poikilocytosis

Many conditions can cause poikilocytosis, variations in the shape of red blood cells.

Sickle Cells—Drepanocytes

Sickle cell disease is an inherited condition in which hemoglobin S causes the red blood cells to have a characteristic *sickle* shape when exposed to decreased levels of oxygen (Figures 2-63 and 2-64A). Another name for a sickle cell is a *drepanocyte*. Because of their abnormal shape, they block the smaller blood vessels, cutting off oxygen to tissues in that area. The lowered oxygen level then causes more red blood cells to change to the sickle shape. This is called a crisis, a serious and painful event for the patient because of damage to vital organs.

Spherocytes

Spherocytes are red blood cells that have lost their biconcave shape (Figures 2-63 and 2-64B). Anemia develops because the spleen recognizes these cells as abnormal and destroys them prematurely.

Elliptocytes

Elliptocytes are elongated, cigar-shaped red blood cells (Figure 2-63). In hereditary elliptocytosis, the patient has large numbers of these abnormal cells. Anemia develops because the spleen destroys these red blood cells and only a small number of normal red blood cells remain.

Stomatocytes

Red blood cells with a linear area of pallor through the center are called stomatocytes because the pale area is shaped like a mouth. These cells occur in the condition known as hereditary stomatocytosis.

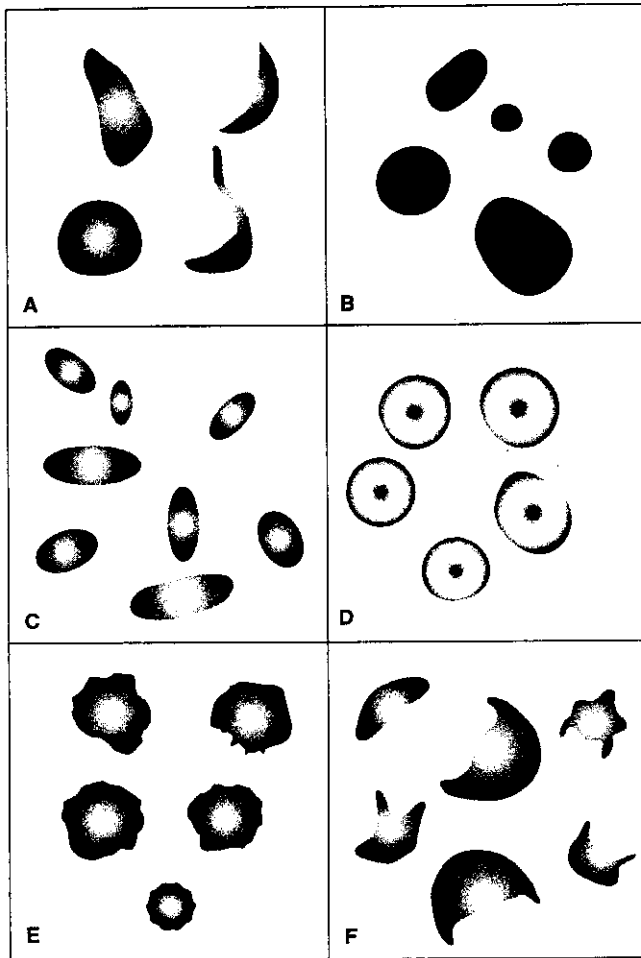


FIGURE 2-63 Morphology of selected abnormal red blood cells: (A) drepanocytes (sickle cells); (B) spherocytes; (C) elliptocytes; (D) codocytes (target cells); (E) crenated cells; and (F) keratocytes including helmet cells

Target Cells—Codocytes

In thalassemia, sickle cell disease, and other hemoglobin abnormalities, red blood cells called codocytes are produced. They are also called target cells because they resemble a bull's eye target (Figures 2-62 and 2-63).

Keratocytes—Schizocytes

Fragmented red blood cells are called either keratocytes or schizocytes. The keratocytes are red blood cells that have been deformed by some mechanical trauma, such as passing through an artificial heart valve or being cut by a fibrin strand in a blood clot (Figures 2-63 and 2-64). When cells are actually sheared into fragments, as may happen in severe burn patients, they are called schizocytes.

Crenated Cells

Crenated red blood cells have bumpy projections on the cell surface (Figure 2-63). These are caused by prolonged exposure of the blood sample to anticoagulant or incorrect blood-to-anticoagulant proportions in the collection tube. These cells should not be confused with pathological cells. When using anticoagulated blood, it is important to make blood smears within



FIGURE 2-64 Photomicrographs of red blood cells found in various conditions: (A) sickle-shaped cells in smear from patient with sickle cell anemia; (B) spherocytes and schizocytes in smear from burn patient; and (C) nucleated red blood cell

2 to 4 hours of the blood being drawn to prevent alterations in blood cell morphology.

Variations in Hemoglobin Content

Red blood cells containing the correct amount of hemoglobin for their size are *normochromic*. A deficiency of hemoglobin due to lack of iron, or another condition, causes the red blood cells to have a large central area of pallor with only a small outer rim of hemoglobin; these cells are *hypochromic* (Figure 2-62). Red blood cells that appear to be completely filled with hemoglobin (have no central area of pallor) are called *hyperchromic*.

Red Blood Cell Inclusions

Basophilic Stippling

Basophilic stippling is caused by the fine granular remnants of RNA and other basophilic substances remaining in the red blood

cell when it loses its nucleus. On a Wright's-stained smear, the RNA remnants cause cells to have a diffuse blue color (diffuse basophilia), orange and blue mottled appearance (polychromatophilia), or punctate fine and coarse granules (basophilic stippling.) These red blood cells are also known as reticulocytes when stained with New Methylene Blue stain.

An occasional stippled cell is normal. An increased number in the peripheral blood smear can indicate certain toxic conditions such as lead poisoning. Stippled cells are also increased in response to increased production of red blood cells due to acute hemorrhage, or after treatment for iron, vitamin B₁₂, or folate deficiency.

Howell-Jolly Bodies

Howell-Jolly bodies are DNA remnants remaining in the red blood cell after the nucleus is lost. They appear on Wright's-stained smears as intense dark blue-purple bodies inside the cell and are common in pernicious anemia and hemolytic anemias.

Cabot Rings

Cabot rings are found in red blood cells in certain anemias and in lead poisoning. They appear as dark blue-purple ring-like structures.

Nucleated Red Blood Cells

Nucleated red blood cells (NRBCs), normally found only in bone marrow, can be seen in peripheral blood in severe anemia. The *metarubricyte* is the form most commonly seen (Figure 2-64). These cells are also present in small numbers in the peripheral blood of normal newborns.

THE RED BLOOD CELL INDICES

The red blood cell (erythrocyte) indices are calculations that estimate the:

- Mean cell volume (MCV)
- Mean cell hemoglobin (MCH)
- Mean cell hemoglobin concentration (MCHC)

These calculations are performed using the red blood cell count and hemoglobin and hematocrit values to define cell size and concentration of hemoglobin within the cell (Figures 2-65, 2-66, and 2-67). Although some information about size and hemoglobin content of red blood cells can be obtained from microscopic examination of the stained smear, the red blood cell indices provide a quantitative measurement of red cell volume and hemoglobin concentration that can be compared to normal reference values.

The indices can be used to classify anemias. However, the validity of the indices is dependent on the accuracy of the RBC count and the hemoglobin and hematocrit determinations. Laboratories with hematology analyzers rely on the instrument to automatically calculate the indices. There may be occasions when the indices must be calculated manually, such as in a smaller laboratory or in research. The formulas for calculating the red cell indices are given in Figures 2-65, 2-66, and 2-67.

$$\text{MCV} = \frac{\text{Hematocrit (percent)}}{\text{RBC}} \times 10$$

Using a hematocrit of 36% and an RBC of $4.0 \times 10^{12}/\text{L}$:

$$\text{MCV} = \frac{36}{4.0} \times 10$$

$$\text{MCV} = 90 \text{ fL (or } \mu\text{m}^3\text{)}$$

FIGURE 2-65 Calculation of mean cell volume (MCV)

$$\text{MCH} = \frac{\text{Hemoglobin (grams)}}{\text{RBC}} \times 10$$

Using a hemoglobin value of 15 g/dL and an RBC of $5.2 \times 10^{12}/\text{L}$:

$$\text{MCH} = \frac{15.0}{5.2} \times 10$$

$$\text{MCH} = 28.8 \text{ pg}$$

FIGURE 2-66 Calculation of mean cell hemoglobin (MCH)

$$\text{MCHC} = \frac{\text{Hemoglobin (grams)}}{\text{Hematocrit (percent)}} \times 100$$

Using a hemoglobin value of 15 g/dL and a hematocrit of 44%:

$$\text{MCHC} = \frac{15}{44} \times 100$$

$$\text{MCHC} = 34\%$$

FIGURE 2-67 Calculation of mean cell hemoglobin concentration (MCHC)

Mean Cell Volume

The mean cell volume (MCV) is the volume of an average red blood cell in a blood sample. The MCV is calculated by using the hematocrit value and the RBC count (Figure 2-65). It is reported in femtoliters (fL). (The MCV was formerly reported in cubic microns.) The normal reference range for MCV is 86 to 98 fL (Table 2-13). An MCV above 98 fL indicates macrocytes; a value below 86 fL indicates microcytes.

Mean Cell Hemoglobin

The mean cell hemoglobin (MCH) estimates the average weight of hemoglobin in a red blood cell. The unit of weight is the picogram (pg), which is equivalent to 10^{-12} g. The MCH is calculated using the hemoglobin value in grams/dL and the RBC count (Figure 2-66). The normal MCH is 27 to 32 pg (Table 2-13). Since the MCH is calculated without using the hematocrit, it is not useful in classifying anemias.

TABLE 2-13. Reference ranges for the red blood cell indices

	REFERENCE RANGE
MCV	86–98 fL
MCH	27–32 pg
MCHC	32%–37%

Mean Cell Hemoglobin Concentration

The mean cell hemoglobin concentration (MCHC) expresses the concentration of hemoglobin in the red blood cells in relation to their size and volume. The MCHC is obtained from calculations using the hemoglobin and the hematocrit (Figure 2-67). The result is expressed in percentage. A value within the reference range of 32% to 37% (Table 2-13) indicates *normochromia*, while a decreased value indicates *hypochromia*.

WHITE BLOOD CELL DISORDERS

Diseases or conditions affecting white blood cells can be detected from the presence of abnormal white blood cells on the peripheral blood smear or from the total white blood cell count (Table 2-14). A white blood cell (WBC) count increased above the normal range is called *leukocytosis*; a count below the normal range is called *leukopenia*. The total WBC count and the types of cells present are usually characteristic for a particular condition.

Leukopenia

Leukopenia is usually defined as a WBC count less than 4×10^9 WBCs/L. A reduction in all white blood cell types is called *balanced leukopenia*; however, in most cases, only one white blood cell type is decreased.

Neutropenia, a reduced number of neutrophils, may be inherited or caused by certain infections, antibiotics, sulfa drugs, and chemotherapy treatments. *Lymphopenia*, a reduced number of lymphocytes, can be caused by exposure to radiation or by

conditions such as lupus erythematosus, cardiac failure, or even stress.

Leukocytosis

Many factors can cause an increase in circulating white blood cells (leukocytosis). Bacterial infections, exercise, anxiety, or pain usually cause leukocytosis and neutrophilia. A *leukemoid reaction* is an excessive response of the white blood cells in which the count can be 50×10^9 /L or higher. The reason for the heightened response is not understood.

In leukemias, the white blood cell increase is almost always an increase in percentage and total number of just one cell line, such as lymphocytes or granulocytes.

Neutrophilia

Neutrophilia is a type of leukocytosis that involves an abnormal increase in the number of the neutrophils. Bacterial infection is the most common cause of neutrophilia (Table 2-14).

In acute infections, neutrophilia is accompanied by an increase in immature neutrophils in the peripheral blood. This is called a shift to the left, in which immature forms known as bands, *metamyelocytes* (juveniles), or *myelocytes* enter the peripheral blood prematurely to help fight the infection (Figure 2-68A). The reference values for these cells in normal adult peripheral blood is one to five bands and zero metamyelocytes and myelocytes (Table 2-15). In mild infections, only the neutrophils and band cells are usually increased. In more severe infections, the WBC count and the neutrophil count can increase, or more bands and metamyelocytes may appear in the peripheral blood. Vacuoles may be present in the cytoplasm of the neutrophils and can indicate a serious infection.

Eosinophilia

Eosinophilia is an abnormal increase in the percentage of eosinophils in the peripheral blood. Eosinophils increase in allergic conditions, parasitic infections, and certain skin diseases.

Basophilia

The number of basophils in the peripheral blood is usually constant and is not affected by exercise, time of day, etc. Basophilia, an abnormal increase in the number of basophils, is usually associated with an

TABLE 2-14. Conditions that affect white blood cell counts and percentages

CONDITION	EFFECT ON WBC COUNTS
Bacterial infections	Increased total white blood cells, increased percentage of neutrophils
Viral infections	Decreased total white blood cells, increased percentage of lymphocytes
Infectious mononucleosis	Increased total white blood cells, increased lymphs, increased atypical lymphs
Parasitic infections, allergic reactions	Increased eosinophils
Leukemias	Total white blood cells usually increased, increase in type of leukocyte involved

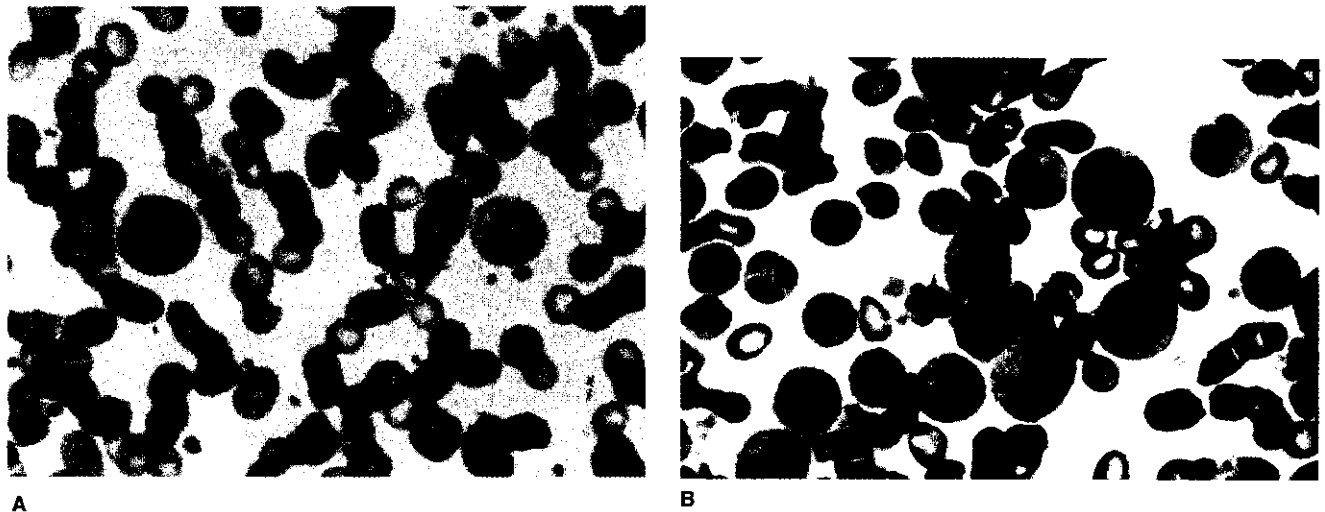


FIGURE 2-68 Photomicrographs showing (A) Neutrophilic shift to the left and (B) myelocytic leukemia

TABLE 2-15. Reference ranges for the white blood cell differential count

TYPE OF CELL	REFERENCE VALUES (%)			
	1 month	6-year-old	12-year-old	Adult
Neutrophil (seg)	15–35	45–50	45–50	50–65
Neutrophil (band)	7–13	0–7	6–8	0–7
Eosinophil	1–3	1–3	1–3	1–3
Basophil	0–1	0–1	0–1	0–1
Monocyte	5–8	4–8	3–8	3–9
Lymphocyte	40–70	40–45	35–40	25–40
Platelets	An average of 7–20 platelets per oil-immersion field is considered normal			

increase in the granulocytes and can be caused by conditions such as ulcerative colitis, chronic sinusitis, and viral infections such as smallpox and chickenpox. Increases in basophils are also seen in *chronic myelogenous leukemia* and *polycythemia vera*.

Monocytosis

Monocytosis, an increase in circulating monocytes, is rare but can occur in tuberculosis, subacute bacterial endocarditis, typhus, and rickettsial infections.

Lymphocytosis

The total lymphocyte count is normally higher in infants and young children than in adults. In adolescents and adults, an increase can be due to acute viral infection, especially infectious mononucleosis. The predominant cell in infectious mononucleosis is the atypical lymphocyte, also called a reactive or variant lymphocyte. Most atypical lymphocytes are characterized by a large nucleus and large amount of blue cytoplasm easily indented by red blood cells; the indentations may cause the lymphocytes to assume a holly-leaf shape (Figure 2-69).

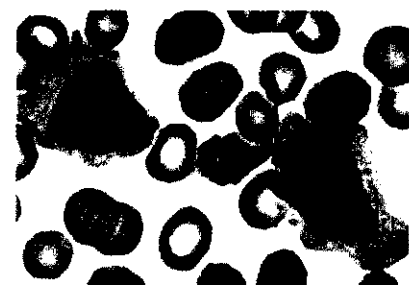


FIGURE 2-69 Photomicrograph showing two atypical lymphocytes (Courtesy of Abbott Laboratories, Abbott Park, IL)

Leukemias

Leukemias are distinguished by unrestrained production of leukocytes in the bone marrow, causing the production of red cells and platelets to be literally “crowded out” by the leukemic white blood cells. Leukemias can be classified as chronic or acute. In general, the survival rates are better for chronic leukemias than for acute leukemias.

CURRENT TOPICS

CHARACTERISTICS OF LEUKEMIAS

In earlier times leukemia was known as *cancer of the blood* or a condition in which the white blood cells were crowding out the red blood cells. Today leukemia, a type of cancer, is defined as an acute or chronic disease characterized by unrestrained growth of the white blood cells and their precursors and with unknown etiologies or causative factors.

Most of the symptoms of leukemia are related to the inability of the bone marrow to produce normal numbers of red blood cells and platelets due to the large numbers of white blood cells in the bone marrow. As a result, the patient develops anemia, fatigue, increased infections, and bleeding problems. In addition, the leukemic white blood cells infiltrate the liver, spleen, lymph nodes, and nervous system, disrupting their normal functions. Blood flow in the smaller vessels such as capillaries can be slowed or stopped due to the large numbers of white blood cells.

The leukemias are classified according to the severity of the disease and the dominant cell involved. *Chronic* leukemias worsen slowly. The total numbers of white blood cells and of abnormal cells are small, the abnormal cells can still function to some extent, and the bone marrow is not affected to a large degree. *Acute* leukemias worsen rapidly and are characterized by abnormal cells that cannot carry out normal immune functions. Leukemias are further classified by the type of white blood cells affected. Leukemia can arise from the *myeloid* line or the *lymphoid* line. Leukemia that arises from the myeloid cells is called *myelogenous*; when it arises from the lymphoid line it is called *lymphocytic*.

The four common types of leukemia are:

- *Chronic lymphocytic leukemia (CLL)*—This type of leukemia affects mostly people over 55 years of age, almost never affects children, and accounts for about 7,000 new cases each year.
- *Chronic myeloid leukemia (CML)*—Also called chronic granulocytic leukemia, this type accounts for about 4,400 new cases each year and mainly affects adults.
- *Acute lymphocytic leukemia (ALL)*—ALL is the most common type in young children and accounts for about 3,800 new cases each year. Adults can also have ALL.
- *Acute myeloid leukemia (AML)*—Also called acute nonlymphocytic leukemia, AML accounts for about 10,000 to 12,000 new cases each year and affects both children and adults. Other rarer types of leukemia account for about 5,200 additional new cases each year.

Some causes of leukemia are known, such as exposure to ionizing radiation that caused leukemia in many Japanese exposed to atomic bomb fallout at the end of WWII. Heredity has also been shown to play a part in developing leukemia; the

siblings and twins of leukemia patients have a greater chance of developing leukemia than the general population. However, other possible causes of leukemia have yet to be proven. Usually, the cause of an individual case cannot be pinpointed.

Factors that have been identified as possible causes of leukemia include:

- Therapeutic radiation for treatment of another type of cancer
- Exposure to chemicals such as benzene or formaldehyde
- Drugs such as chloramphenicol, phenylbutazone, and certain chemotherapy agents
- Viruses, especially retroviruses

New treatments for leukemia are constantly being developed. What works for one patient may not work for another. Treatment consists of four basic types:

- Chemotherapy is a mainstay of leukemia treatment. Chemotherapy agents kill leukemic cells but also damage or kill normal cells. Improvements in chemotherapy include *targeted therapy* in which drugs target only the leukemic cells.
- Radiation therapy uses high-energy rays directed at specific organs such as the spleen or brain to kill leukemia cells.
- Biological therapy is one of the newer forms of treatment in which monoclonal antibodies or interferon is used. Monoclonal antibodies are used against the abnormal cells in CLL; interferon has been found to be an effective treatment in CML.
- Stem cell transplants have been used for several years and have several variations. The patient is treated with high doses of drugs or radiation (or both), resulting in the destruction of both leukemic cells and normal cells in the bone marrow. The patient then receives a stem cell transplant from which new blood cells can develop. These stem cells can come from bone marrow transplantation, peripheral stem cell transplantation, or umbilical cord blood transplantation. Of the three, the public is probably most familiar with bone marrow transplants. The donated marrow usually comes from a donor whose tissue has been matched to the patient by tissue typing. In other cases, the patient's own blood cells can be harvested before the patient is subjected to whole body radiation. These harvested cells are treated to kill the leukemia cells, then frozen and stored until transfused back into the patient after radiation or chemotherapy is completed.

Although leukemia continues to cause many deaths each year, much progress has been made in the diagnosis, classification, and treatment of the disease. The hope is that, once specific causes are identified, the cause can be avoided or eliminated, and improved treatments will result in leukemia simply being another curable disease.

In acute leukemias, immature blood cells called blast cells and other immature forms of white blood cells are the predominant cells in the peripheral circulation (Figure 2-68B). Blast cells are the earliest identifiable blood cell precursors and are normally found only in the bone marrow. The total WBC count is usually, but not always, elevated in acute leukemia. Usually, the platelet count is decreased and anemia is present because leukemic cells affect the production of other cells in the bone marrow.

Chronic leukemias are characterized by leukocytosis with WBC counts of $50,000 \times 10^9/L$ or greater. In the peripheral circulation, the predominant cells are mature cells along with some immature forms of the same cell type as well as some blast cells.

Diagnosing leukemias is a task for pathologists and hematology specialists. However, many cases are first noticed by a technologist performing a differential or because a hematology analyzer flags a sample as abnormal. It is critical for the technologist to carefully perform every differential and to closely examine all the characteristics of any cells that appear different. Sometimes it is necessary to count 200 to 500 leukocytes to find more of the abnormal cells.

PLATELET DISORDERS

Platelets can be abnormal in number or in function. In *thrombocytopenia*, platelet numbers fall below the reference range. Many factors can cause decreased platelets, including radiation exposure, certain drugs, chronic alcoholism, platelet destruction by the spleen, and the effect of diseases such as leukemia on bone marrow.

Elevation of platelet numbers above the reference range is called *thrombocytosis*. Some causes of thrombocytosis include a reaction to inflammatory conditions, a secondary reaction to other blood disorders, and removal of the spleen. Platelet disorders are discussed in Lesson 3-2.

SAFETY Reminders

Observe Standard Precautions when preparing and staining peripheral blood smears.

Take care to avoid cuts from the sharp edges of the glass slides

Use appropriate PPE to avoid skin, eye, or mucus membrane exposure to stains and methanol.



PROCEDURAL Reminders

Follow the institution's written procedure for reporting differential counts. QA

Follow the institution's written procedure for reporting abnormal cells.

Follow all policies related to patient identification and sample collection.

Only technologists competent in blood cell identification should perform and report differential counts.

Abnormal findings should be verified by the appropriate supervisor.

SUMMARY

The technologist must remember that any smear being examined may contain abnormal blood cells even though the patient seems in good health. The peripheral blood smear must be properly prepared and stained. The technologist must be very familiar with normal and abnormal blood cell morphology to accurately identify and evaluate the morphology of cells observed during the differential. A more experienced and knowledgeable technologist or the laboratory director must be consulted before certain types of abnormal cells are reported, depending on the particular healthcare facility's policy.

This lesson is only an elementary introduction to the morphology of abnormal blood cells. It is not possible to adequately cover the subject in this space; complete books have been written about each of these cell lines and the disorders associated with their abnormalities. It is hoped that this lesson will stimulate students and instructors to have the desire to know more about disorders of the white blood cells, red blood cells, and platelets.

REVIEW QUESTIONS

1. Why is it important to recognize an abnormal blood cell?
2. List three conditions in which abnormal red blood cell morphology can be found.
3. Why is it important to report red blood cell inclusions?
4. How can red blood cell indices be used to classify anemias?
5. List three conditions in which abnormal white blood cell morphology can be found.
6. What is leukemia?

7. Discuss the differences between acute and chronic leukemias.
8. Why do leukemia patients develop anemia?
9. List one cause of thrombocytosis and one cause of thrombocytopenia.
10. Define basophilia, basophilic stippling, blast cell, codocyte, crenated cell, drepanocyte, elliptocyte, eosinophilia, femtoliter, folic acid, Howell-Jolly body, keratocyte, leukemia, mean cell hemoglobin, mean cell hemoglobin concentration, mean cell volume, neutrophilia, nucleated red blood cell,

picogram, red blood cell indices, schizocyte, shift to the left, sickle cell, sickle cell anemia, stomatocyte, target cell, thalassemia, and vitamin B₁₂.

STUDENT ACTIVITIES

1. Practice recognizing and identifying abnormal blood cells as outlined in the Student Performance Guide.
2. Practice calculating the red blood cell indices.

WEB ACTIVITY

Search the Internet for information on treatments for leukemia. Prepare a short report on the latest treatment regimen for one of the leukemias.