Leukemia–Acute Myeloid (Myelogenous)

What is acute myeloid leukemia?

Cancer starts when cells in a part of the body begins to grow out of control and can spread to other areas of the body. There are many kinds of cancer. Cells in nearly any part of the body can become cancer. To learn more about how cancers start and spread, go to What Is Cancer?

Leukemias are cancers that start in cells that would normally develop into different types of blood cells. Here we will talk about acute myeloid leukemia (AML).

Acute myeloid leukemia (AML) has many other names, including acute myelocytic leukemia, acute myelogenous leukemia, acute granulocytic leukemia, and acute non-lymphocytic leukemia.

“Acute” means that this leukemia can progress quickly if not treated, and would probably be fatal in a few months. “Myeloid” refers to the type of cell this leukemia starts from.

Most cases of AML develop from cells that would turn into white blood cells (other than lymphocytes), but some cases of AML develop in other types of blood-forming cells. The different types of AML are listed in the section “How is acute myeloid leukemia classified?”

AML starts in the bone marrow (the soft inner part of certain bones, where new blood cells are made), but in most cases it quickly moves into the blood. It can sometimes spread to other parts of the body including the lymph nodes, liver, spleen, central nervous system (brain and spinal cord), and testicles.

Other types of cancer can start in these organs and then spread to the bone marrow. But these cancers that start elsewhere and then spread to the bone marrow are not leukemias.
Normal bone marrow, blood, and lymphoid tissue

To understand the different types of leukemia, it helps to know about the blood and lymph systems.

Bone marrow

Bone marrow is the soft inner part of some bones such as the skull, shoulder blades, ribs, pelvic (hip) bones, and backbones. The bone marrow is made up of a small number of blood stem cells, more mature blood-forming cells, fat cells, and supporting tissues that help cells grow.

Inside the bone marrow, blood stem cells develop into new blood cells. During this process, the cells become either lymphocytes (a kind of white blood cell) or other blood-forming cells, which are types of myeloid cells. These other blood-forming cells can develop into red blood cells, white blood cells (other than lymphocytes), or platelets.

Types of blood cells

Red blood cells carry oxygen from the lungs to all other tissues in the body, and take carbon dioxide back to the lungs to be removed. Having too few red blood cells in the body (called anemia) can make you feel tired, weak, and short of breath because your body tissues are not getting enough oxygen.

Platelets are actually cell fragments made by a type of bone marrow cell called the megakaryocyte. Platelets are important in stopping bleeding. They help plug up holes in blood vessels caused by cuts or bruises. Having too few platelets (called thrombocytopenia) may cause you to bleed or bruise easily.

White blood cells help the body fight infections. Having too few white blood cells weakens your immune system and can make you more likely to get an infection.

Types of white blood cells

Lymphocytes are mature, infection-fighting cells that develop from lymphoblasts, a type of blood stem cell in the bone marrow. Lymphocytes are the main cells that make up lymphoid tissue, a major part of the immune system. Lymphoid tissue is found in lymph nodes, the thymus (a small organ behind the breast bone), the spleen, the tonsils and adenoids, and is scattered throughout the digestive and respiratory systems and the bone marrow. There are 2 main types of lymphocytes:

- B lymphocytes (B cells) protect the body from invading germs by developing (maturing) into plasma cells, which make proteins called antibodies. The antibodies attach to the germs (bacteria, viruses, and fungi), which helps other types of white blood cells recognize and destroy them.
• **T lymphocytes** (T cells) can recognize cells infected by viruses and directly destroy these cells. They also help regulate the immune response.

**Granulocytes** are mature, infection-fighting cells that develop from myeloblasts, a type of blood-forming cell in the bone marrow. Granulocytes have granules that show up as spots under the microscope. These granules contain enzymes and other substances that can destroy germs, such as bacteria. The 3 types of granulocytes – neutrophils, basophils, and eosinophils – are distinguished by the size and color of their granules.

**Monocytes** develop from blood-forming monoblasts in the bone marrow and are related to granulocytes. After circulating in the bloodstream for about a day, monocytes enter body tissues to become macrophages, which can destroy some germs by surrounding and digesting them. Macrophages also help lymphocytes recognize germs and make antibodies to fight them.

Any of the blood-forming myeloid or lymphoid cells from bone marrow can turn into a leukemia cell. Once this change takes place, the leukemia cells no longer mature in a normal way. Leukemia cells often reproduce quickly, but in most cases the problem is that they don’t die when they should. They survive and build up in the bone marrow. Over time, these cells spill into the bloodstream and spread to other organs, where they can keep other cells in the body from doing their jobs.

**Types of leukemia**

Not all leukemias are the same. There are 4 main types of leukemia. Knowing the specific type helps doctors better predict each patient’s prognosis (outlook) and select the best treatment.

**Acute leukemia versus chronic leukemia**

The first factor in classifying a patient’s leukemia is whether most of the abnormal cells look like normal white blood cells (mature) or look more like stem cells (immature).

In **acute leukemia**, the leukemia cells are immature blood cells (called blasts). These leukemias are fast growing because normal blast cells divide quickly. But the leukemia cells don’t divide any more often than normal blast cells do. They just don’t stop dividing when normal blast cells would. Without treatment, most patients with acute leukemia would live only a few months. Some types of acute leukemia respond well to treatment, and many patients can be cured. Other types of acute leukemia have a less favorable outlook.

In **chronic leukemia**, the leukemia cells are more mature cells, but they are not completely normal. They generally don’t fight infection as well as normal white blood cells. And they survive longer, build up, and crowd out normal cells. Chronic leukemias tend to progress over a longer period of time, and most patients can live with them for many years. But chronic leukemias are generally harder to cure than acute leukemias.
Myeloid leukemia versus lymphocytic leukemia

The other main factor in classifying leukemia is the type of bone marrow cells that are affected.

Myeloid leukemias start in immature forms of myeloid cells – white blood cells (other than lymphocytes), red blood cells, or platelet-making cells (megakaryocytes). They are also known as myelocytic, myelogenous, or non-lymphocytic leukemias.

Lymphocytic leukemias start in immature forms of lymphocytes. They are also known as lymphoid or lymphoblastic leukemias. Lymphomas are also cancers that start in lymphocytes. But whereas lymphocytic leukemias develop from cells in the bone marrow, lymphomas develop from cells in lymph nodes or other organs.

By considering whether leukemias are acute or chronic and whether they are myeloid or lymphocytic, they can be divided into 4 main types:

- Acute myeloid (or myelogenous) leukemia (AML)
- Chronic myeloid (or myelogenous) leukemia (CML)
- Acute lymphocytic (or lymphoblastic) leukemia (ALL)
- Chronic lymphocytic leukemia (CLL)

The rest of this document focuses on acute myeloid leukemias in adults only. Chronic leukemias in adults and acute lymphocytic leukemia (ALL) in adults are discussed in other American Cancer Society documents. For information on AML in children, please see Childhood Leukemia.

What are the key statistics about acute myeloid leukemia?

The American Cancer Society’s estimates for leukemia in the United States for 2015 are:

- About 54,270 new cases of leukemia (all kinds) and 24,450 deaths from leukemia (all kinds)
- About 20,830 new cases of acute myeloid leukemia (AML). Most will be in adults.
- About 10,460 deaths from AML. Almost all will be in adults.

Acute myeloid leukemia is generally a disease of older people and is uncommon before the age of 45. The average age of a patient with AML is about 67 years.

AML is slightly more common among men than among women, but the average lifetime risk in both sexes is less than ½ of 1%.
Information on treatment success rates for AML in adults can be found in the section “Treatment response rates for acute myeloid leukemia.”

**What are the risk factors for acute myeloid leukemia?**

A risk factor is something that affects your chance of getting a disease, such as cancer. Different cancers have different risk factors. Some risk factors, like smoking, can be changed. Others, like a person’s age or family history, can’t be changed.

But having a risk factor, or even several risk factors, does not mean that you definitely will get the disease. And many people who get the disease may have few or no known risk factors. Even if a person has a risk factor and develops cancer, it’s often very hard to know how much that risk factor contributed to the cancer.

There are some known risk factors for acute myeloid leukemia (AML).

**Smoking**

The only proven lifestyle-related risk factor for AML is smoking. Many people know that smoking is linked to cancers of the lungs, mouth, throat, and larynx (voice box), but few realize that it can also affect cells that don’t come into direct contact with smoke. Cancer-causing substances in tobacco smoke are absorbed by the lungs and spread through the bloodstream to many parts of the body.

**Certain chemical exposures**

The risk of AML is increased by exposure to certain chemicals.

For example, long-term exposure to high levels of benzene is a risk factor for AML. Benzene is a solvent used in the rubber industry, oil refineries, chemical plants, shoe manufacturing, and gasoline-related industries, and is also found in cigarette smoke, gasoline and motor vehicle exhaust, and some glues, cleaning products, detergents, art supplies, and paints.

Some studies have linked heavy workplace exposure to formaldehyde with AML risk, but this link has not been seen in some other studies.

**Certain chemotherapy drugs**

Patients with cancer who are treated with certain chemotherapy (chemo) drugs are more likely to develop AML.
Drugs called alkylating agents and platinum agents are linked to an increased risk of AML that peaks about 8 years after chemo. Often a patient will get a disease called myelodysplastic syndrome before the AML. Examples of alkylating agents include cyclophosphamide, mechlorethamine, procarbazine, chlorambucil, melphalan, busulfan, and carmustine. Platinum drugs include cisplatin and carboplatin.

Chemo drugs known as topoisomerase II inhibitors are also linked to AML. AML linked to these drugs tends to occur only a few years after treatment and without myelodysplastic syndrome developing first. Examples of topoisomerase II inhibitors include etoposide, teniposide, mitoxantrone, epirubicin, and doxorubicin.

For more information, see our document Second Cancers in Adults.

**Radiation exposure**

High-dose radiation exposure (such as being a survivor of an atomic bomb blast or nuclear reactor accident) increases the risk of developing AML. Japanese atomic bomb survivors had a greatly increased risk of developing acute leukemia, most often about 6 to 8 years after exposure.

Radiation treatment for cancer has also been linked to an increased risk of AML. The risk varies based on the amount of radiation given and what area is treated, but is not as high as was seen after the atomic bomb blasts.

The possible risks of leukemia from exposure to lower levels of radiation, such as from imaging tests like x-rays or CT scans, are not well-defined. If a fetus is exposed to radiation within the first months of development, it may carry an increased risk of leukemia, but the extent of the risk is not clear. If there is an increased risk it is likely to be small, but to be safe, most doctors try to limit radiation exposure from tests as much as possible, especially in children and pregnant women.

For more information, see our document X-rays, Gamma Rays and Cancer Risk.

**Certain blood disorders**

People with certain blood disorders seem to be at increased risk for getting AML. These include chronic myeloproliferative disorders such as polycythemia vera, essential thrombocythemia, and idiopathic myelofibrosis. The risk of AML is increased further if treatment for these disorders includes some types of chemotherapy or radiation.

Some people who have myelodysplastic syndrome (MDS) may develop AML. Patients with MDS have low blood cell counts and abnormal cells in the blood and bone marrow. MDS can evolve over time into AML. Patients who develop AML after having MDS typically have a poor prognosis.
Genetic syndromes

Some syndromes that are caused by genetic mutations (abnormal changes) present at birth seem to raise the risk of AML. These include:

- Fanconi anemia
- Bloom syndrome
- Ataxia-telangiectasia
- Diamond-Blackfan anemia
- Schwachman-Diamond syndrome
- Li-Fraumeni syndrome
- Neurofibromatosis type 1
- Severe congenital neutropenia (also called Kostmann syndrome)

Some chromosome problems present at birth are also linked to a higher risk of AML, including:

- Down syndrome (being born with an extra copy of chromosome 21)
- Trisomy 8 (being born with an extra copy of chromosome 8)

Family history

Although most cases of AML are not thought to have a strong genetic link, having a close relative (such as a parent or sibling) with AML increases your risk of getting the disease.

Someone who has an identical twin who got AML before they were a year old has a very high risk of also getting AML.

Older age

AML can occur at any age, but it becomes more common as people get older.

Male gender

AML is more common in males than in females. The reason for this is not clear.
Uncertain, unproven or controversial risk factors

Other factors that have been studied for a possible link to AML include:

- Exposure to electromagnetic fields (such as living near power lines)
- Workplace exposure to diesel, gasoline, and certain other chemicals and solvents
- Exposure to herbicides or pesticides

So far, none of these factors has been linked conclusively to AML. Research in these areas is ongoing.

Do we know what causes acute myeloid leukemia?

Some people with acute myeloid leukemia (AML) have one or more known risk factors (see the section “What are the risk factors for acute myeloid leukemia?”), but many do not. Even when a person has one or more risk factors, there is no way to tell if it actually caused the cancer.

Scientists have learned how certain changes in DNA can cause normal bone marrow cells to become leukemia cells. Normal human cells grow and function based on the information contained in each cell’s chromosomes. Chromosomes are long strands of DNA in each cell. The DNA inside our cells makes up our genes – the instructions for how our cells function. We tend to look like our parents because they are the source of our DNA. But our genes affect more than how we look.

Some genes control when our cells grow, divide to make new cells, and die at the right time. Certain genes that help cells grow, divide, or live longer are called oncogenes. Others that slow down cell division or make cells die at the right time are called tumor suppressor genes.

Each time a cell prepares to divide into 2 new cells, it must make a new copy of the DNA in its chromosomes. This process is not perfect, and errors can occur that affect genes within the DNA. Cancers can be caused by DNA mutations (changes) that turn on oncogenes or turn off tumor suppressor genes. For instance, changes in certain genes such as FLT3, c-KIT, and RAS are common in AML cells. These types of changes can help cells grow out of control.

Mutations in specific genes are found in many cases of AML, but larger changes in one or more chromosomes are also common. Even though these changes involve larger pieces of DNA, their effects are still likely to be due to changes in just one or a few genes that are on that part of the chromosome. Several types of chromosome changes may be found in AML cells:
Translocations are the most common type of DNA change that can lead to leukemia. A translocation means that a part of one chromosome breaks off and becomes attached to a different chromosome. The point at which the break occurs can affect nearby genes – for example, it can turn on oncogenes or turn off genes like \textit{RUNX1} and \textit{RARa}, which would normally help blood cells to mature.

Deletions occur when part of a chromosome is lost. This can result in the cell losing a gene that helped keep its growth in check (a tumor suppressor gene).

Inversions occur when part of a chromosome gets turned around, so it’s now in reverse order. This can result in the loss of a gene (or genes) because the cell can no longer read its instructions (much like trying to read a book backwards).

Addition or duplication means that there is an extra chromosome or part of a chromosome. This can lead to too many copies of certain genes within the cell. This can be a problem if one or more of these genes are oncogenes.

Different cases of AML can have different chromosome changes, and some changes are more common than others. Doctors are trying to figure out why these changes occur and how each of them might lead to leukemia. For example, some are more common in leukemia that occurs after chemotherapy for another cancer.

Some changes seem to have more of an effect on a person’s prognosis (outlook) than others. For instance, they may affect how quickly the leukemia cells grow, or how likely they are to respond to treatment. This is discussed in more detail in the section “How is acute myeloid leukemia classified?”

Some people with certain types of cancer have inherited DNA mutations from a parent that increase their risk for the disease. Although this can happen in some cases of AML, such as in the genetic syndromes discussed in the risk factors section, inherited mutations are not often a cause in AML.

Most DNA changes related to AML occur during a person’s lifetime, rather than having been inherited before birth. Some of these acquired changes may have outside causes like radiation or cancer-causing chemicals, but in most cases the reason they occur is not known. They seem to happen more often as we age, which might help explain why AML usually occurs in older people.

Can acute myeloid leukemia be prevented?

It’s not clear what causes most cases of acute myeloid leukemia (AML). Since most people with AML don’t have risk factors that can be changed, at the present time there is no known way to prevent most cases of AML.

Smoking is by far the most significant controllable risk factor for AML, and quitting offers the greatest chance to reduce a person’s risk of AML. Of course, non-smokers are also much
less likely than smokers to develop many other cancers, as well as heart disease, stroke, and some other diseases.

Treating some other cancers with chemotherapy and radiation may cause secondary (post-treatment) leukemias. Doctors are trying to figure out how to treat these cancers without raising the risk of secondary leukemia. But for now, the obvious benefits of treating life-threatening cancers with chemotherapy and radiation must be balanced against the small chance of getting leukemia years later.

Avoiding known cancer-causing chemicals, such as benzene, can lower the risk of getting AML. But most experts agree that exposure to workplace and environmental chemicals seems to account for only a small portion of leukemia cases.

**Can acute myeloid leukemia be found early?**

For many types of cancer, finding the cancer early makes it easier to treat. The American Cancer Society recommends screening tests for early detection of certain cancers in people without any symptoms.

But at this time, there are no special tests recommended to find acute myeloid leukemia (AML) early. The best way to find leukemia early is to report any possible symptoms of leukemia to the doctor right away.

Some people are known to be at increased risk of AML because they have certain blood disorders (such as myelodysplastic syndrome) or inherited disorders (such as Down syndrome), or because they were treated with certain chemotherapy drugs or radiation. Most doctors recommend that these people get careful, regular medical checkups. These people don’t usually develop leukemia, but they and their doctors should be familiar with the possible symptoms of AML.

**Signs and symptoms of acute myeloid leukemia**

Acute myeloid leukemia (AML) can cause many different signs and symptoms. Some are more common with certain subtypes of AML.

**General symptoms**

Patients with AML often have several non-specific (general) symptoms. These can include:

- Weight loss
- Fatigue
• Fever
• Night sweats
• Loss of appetite

Of course, these are not just symptoms of AML, and more often are caused by something other than leukemia.

**Problems caused by low numbers of blood cells**

Many signs and symptoms of AML result from a shortage of normal blood cells, which happens when the leukemia cells crowd out the normal blood-making cells in the bone marrow. As a result, people do not have enough normal red blood cells, white blood cells, and blood platelets. These shortages show up on blood tests, and they can also cause symptoms.

**Symptoms from low red blood cell counts (anemia):** Red blood cells carry oxygen to all of the cells in the body. A shortage of red blood cells can cause:

• Tiredness (fatigue)
• Weakness
• Feeling cold
• Feeling dizzy or lightheaded
• Headaches
• Shortness of breath

**Symptoms from low white blood cell counts:** Infections can occur because of a shortage of normal white blood cells (called *leukopenia*) or a shortage of normal neutrophils (called *neutropenia*). Neutrophils are a type of white blood cell needed to fight infections from bacteria. Patients with AML can get infections that don’t seem to go away or may get one infection after another. Fever often goes along with the infection.

Although people with AML may have high white blood cell counts due to excess numbers of leukemia cells, these cells don’t protect against infection the way normal white blood cells do.

**Symptoms from low blood platelet counts:** Platelets in the blood normally help stop bleeding. A shortage of blood platelets (called *thrombocytopenia*) can lead to:

• Excess bruising and bleeding
• Frequent or severe nosebleeds
• Bleeding gums

**Symptoms caused by high numbers of leukemia cells**

The cancer cells in AML (called *blasts*) are bigger than normal white blood cells and have more trouble going through tiny blood vessels. If the blast count gets very high, these cells can clog up blood vessels and make it hard for normal red blood cells (and oxygen) to get to tissues. This is called *leukostasis*. Leukostasis is rare, but it is a medical emergency that needs to be treated right away. Some of the symptoms are like those seen with a stroke, and include:

• Headache
• Weakness in one side of the body
• Slurred speech
• Confusion
• Sleepiness

When blood vessels in the lungs are affected, patients have problems with shortness of breath. Blood vessels in the eye can be affected as well, leading to blurry vision or even loss of vision.

**Bleeding and clotting problems**

Patients with a certain type of AML called *acute promyelocytic leukemia* (APL) might go to the doctor with problems with bleeding and clotting. They may have a nose bleed that won’t stop, or a cut that won’t stop oozing. They may also have calf swelling from a blood clot called a *deep venous thrombosis* (DVT) or chest pain and shortness of breath from a blood clot in the lung (called a *pulmonary embolism* or *PE*).

**Bone or joint pain**

Some patients have bone pain or joint pain caused by the buildup of leukemia cells in these areas.

**Swelling in the abdomen**

Leukemia cells may collect in the liver and spleen, causing them to enlarge. This may be noticed as a fullness or swelling of the belly. The lower ribs usually cover these organs, but when they are enlarged the doctor can feel them.
Spread to the skin

If leukemia cells spread to the skin, they can cause lumps or spots that may look like common rashes. A tumor-like collection of AML cells under the skin or other parts of the body is called a chloroma, granulocytic sarcoma, or myeloid sarcoma. Rarely, AML can first appear as only a chloroma with no leukemia cells in the bone marrow.

Spread to the gums

Certain types of AML may spread to the gums, causing swelling, pain, and bleeding.

Spread to other organs

Sometimes, leukemia cells can spread to other organs. Spread to the brain and spinal cord can cause symptoms such as:

- Headaches
- Weakness
- Seizures
- Vomiting
- Trouble with balance
- Facial numbness
- Blurred vision

On rare occasions AML can spread to the eyes, testicles, kidneys, or other organs.

Enlarged lymph nodes

In rare cases, AML can spread to lymph nodes (bean-sized collections of immune cells throughout the body), causing them to get bigger. Affected nodes in the neck, groin, underarm areas, or above the collarbone may be felt as lumps under the skin.

Although any of the symptoms and signs above may be caused by AML, they can also be caused by other conditions. Still, if you have any of these problems, it’s important to see a doctor so the cause can be found and treated, if needed.

How is acute myeloid leukemia diagnosed?

Certain signs and symptoms might suggest that a person could have acute myeloid leukemia (AML), but tests are needed to confirm the diagnosis.
Medical history and physical exam

If signs or symptoms suggest you might have leukemia, the doctor will want to get a thorough medical history, including how long you have had symptoms and whether or not you have any risk factors.

During the physical exam, the doctor will likely pay close attention to your eyes, mouth, skin, lymph nodes, liver, spleen, and nervous system, and will look for areas of bleeding or bruising, or possible signs of infection.

If there is reason to think there might be problems caused by abnormal blood cells (anemia, infections, bleeding or bruising, etc.), you will get tests to check your blood cell counts. You might also be referred to a hematologist, a doctor who specializes in diseases of the blood (including leukemia).

Types of samples used to test for acute myeloid leukemia

If signs and symptoms and/or the results of the physical exam suggest you might have leukemia, the doctor will need to check samples of cells from your blood and bone marrow to be sure. Other tissue and cell samples may also be taken in order to help guide treatment.

Blood samples

Blood samples for tests for AML are generally taken from a vein in the arm.

Bone marrow samples

Bone marrow samples are obtained from 2 tests that are usually done at the same time:

- Bone marrow aspiration
- Bone marrow biopsy

The samples are usually taken from the back of the pelvic (hip) bone, but sometimes other bones are used instead. If only an aspiration is to be done, it may be taken from the sternum (breast bone).

In bone marrow aspiration, you lie on a table (either on your side or on your belly). The doctor will clean the skin over the hip and then numb the area and the surface of the bone by injecting a local anesthetic. This may cause a brief stinging or burning sensation. A thin, hollow needle is then inserted into the bone, and a syringe is used to suck out a small amount of liquid bone marrow. Even with the anesthetic, most patients still have some brief pain when the marrow is removed.

A bone marrow biopsy is usually done just after the aspiration. A small piece of bone and marrow is removed with a slightly larger needle that is pushed down into the bone. This
causes a feeling of pressure and may also cause some brief pain. Once the biopsy is done, pressure will be applied to the site to help prevent bleeding.

These bone marrow tests are used to help diagnose leukemia, but they are also repeated later to tell if the leukemia is responding to treatment.

**Spinal fluid**

The cerebrospinal fluid (CSF) is the liquid that surrounds the brain and spinal cord. AML can sometimes spread to the area around the brain and spinal cord. To check for this spread, doctors remove a sample of CSF for testing. The procedure used to remove this fluid is called a *lumbar puncture* (*spinal tap*). A lumbar puncture is not often used to test for AML, unless the patient is having symptoms that could be caused by leukemia cells spreading into the brain and spinal cord.

For this test, the patient may lie on his side or sit up. The doctor first numbs an area of skin on the lower part of the back over the spine. A small, hollow needle is then inserted between the bones of the spine into the area around the spinal cord to withdraw some of the fluid. A lumbar puncture is sometimes used to deliver chemotherapy drugs into the CSF to help prevent or treat the spread of leukemia to the spinal cord and brain.

**Lab tests used to diagnose and classify acute myeloid leukemia**

One or more of the following lab tests may be done on the samples to diagnose AML and/or to determine the specific subtype of AML.

**Complete blood count and peripheral blood smear**

The complete blood count (CBC) is a test that measures the amounts of different cells in the blood, such as the red blood cells, white blood cells, and platelets. This test is often done along with a differential (or diff), which looks at the numbers of the different types of white blood cells. For the peripheral blood smear, a sample of blood is looked at under the microscope. Changes in the numbers and the appearance of different types of blood cells often help diagnose leukemia.

Most patients with AML have too many immature white cells in their blood, and not enough red blood cells or platelets. Many of the white blood cells may be myeloblasts (often just called *blasts*), which are immature blood-forming cells that are not normally found in the blood. These immature cells don’t work like normal, mature white blood cells. These findings may suggest leukemia, but the disease usually is not diagnosed without looking at a sample of bone marrow cells.
Blood chemistry and coagulation tests

These tests measure the amounts of certain chemicals in the blood and the ability of the blood to clot. These tests are not used to diagnose leukemia, but they can help detect liver or kidney problems, abnormal levels of certain minerals in the blood, or problems with blood clotting.

Routine microscopic exams

Samples of blood, bone marrow, or CSF are looked at under a microscope by a pathologist (a doctor specializing in lab tests) and may be reviewed by the patient’s hematologist/oncologist (a doctor specializing in cancer and blood diseases).

The doctors will look at the size, shape, and other traits of the white blood cells in the samples to classify them into specific types.

A key element is whether the cells look mature (like normal blood cells) or immature (lacking features of normal blood cells). The most immature cells are called myeloblasts (or blasts for short).

The percentage of blasts in the bone marrow or blood is particularly important. Having at least 20% blasts in the marrow or blood is generally required for a diagnosis of AML. It can also be diagnosed if the blasts are found (using another test) to have a chromosome change that occurs only in a specific type of AML, even if the blast percentage doesn’t reach 20%. Sometimes the blasts look like normal immature cells in the bone marrow. But in normal bone marrow, the blast count is 5% or less.

Sometimes just counting and looking at the cells isn’t enough to provide a clear diagnosis. Additional tests may be used to confirm the diagnosis of AML.

Cytochemistry

For cytochemistry tests, cells are exposed to chemical stains (dyes) that react with only some types of leukemia cells. These stains cause color changes that can be seen under a microscope, which can help the doctor determine what types of cells are present. For instance, one stain can help distinguish AML cells from acute lymphocytic leukemia (ALL) cells. The stain causes the granules of most AML cells to appear as black spots under the microscope, but it does not cause ALL cells to change colors.

Flow cytometry and immunohistochemistry

Flow cytometry is often used to look at the cells from bone marrow and blood samples. It is very helpful in determining the exact type of leukemia.

The test looks for certain substances on the surface of cells that help identify what types of cells they are. A sample of cells is treated with special antibodies (man-made immune system
proteins) that stick to the cells only if they have these substances. The cells are then passed in front of a laser beam. If the cells now have antibodies attached to them, the laser will make them give off light, which can be measured and analyzed by a computer. Groups of cells can be separated and counted by these methods.

In immunohistochemistry tests, cells from the blood or bone marrow samples are also treated with special antibodies. But instead of using a laser and computer, the sample is treated so that certain types of cells change color when seen under a microscope.

These tests are used for *immunophenotyping* – classifying leukemia cells according to the substances (antigens) on their surfaces. Leukemia cells can have different antigens depending on which type of cells they start in and how mature they are, and this information can be helpful in AML classification.

**Cytogenetics**

For this test, a cell’s chromosomes (long strands of DNA) are looked at under a microscope. Normal human cells contain 23 pairs of chromosomes, each of which are a certain size and stain a certain way. In some cases of AML, the cells have chromosome changes that can be seen under a microscope.

For instance, 2 chromosomes may swap some of their DNA, so that part of one chromosome becomes attached to part of a different chromosome. This change, called a *translocation*, can usually be seen under a microscope. Other types of chromosome changes are also possible (see below). Recognizing these changes can help identify certain types of AML and can be important in determining a patient’s outlook.

It usually takes about 2 to 3 weeks to get results for this test because the leukemia cells must be grown in lab dishes for a couple of weeks before their chromosomes can be looked at under the microscope.

The results of cytogenetic testing are written in a shorthand form that describes the chromosome changes:

- A *translocation*, written as t(8;21), for example, means a part of chromosome 8 is now located on chromosome 21, and vice versa.
- An *inversion*, written as inv(16), for example, means that part of the chromosome 16 is now in reverse order but is still attached to the chromosome.
- A *deletion*, written as del(7) or -7, for example, indicates part of chromosome 7 has been lost.
- An *addition or duplication*, +8, for example, means that all or part of chromosome 8 has been duplicated, and too many copies of it are found within the cell.
Not all chromosome changes can be seen under a microscope. Other lab tests can often detect these changes.

**Fluorescent in situ hybridization (FISH)**

This is similar to cytogenetic testing. It uses special fluorescent dyes that only attach to specific genes or parts of particular chromosomes. FISH can find the chromosome changes (such as translocations) that are visible under a microscope in standard cytogenetic tests, as well as some changes too small to be seen with usual cytogenetic testing.

FISH can be used to look for changes in specific genes or parts of chromosomes. It can be used on regular blood or bone marrow samples without growing them in a lab first. This means the results are often available more quickly than with regular cytogenetic testing. The drawback is that it only looks for certain gene or chromosome changes, so the doctor has to know what he or she is looking for before the test is run.

**Polymerase chain reaction (PCR)**

This is a very sensitive test that can also find some gene and chromosome changes too small to be seen under a microscope. It is helpful in finding gene changes that are in only a few cells, making it good for finding small numbers of leukemia cells in a sample (like after treatment). Like FISH, this test only looks for certain gene or chromosome changes, so the doctor has to know what he or she is looking for before the test is run.

**Imaging tests for acute myeloid leukemia**

Imaging tests use x-rays, sound waves, magnetic fields, or radioactive particles to create pictures of the inside of the body. Leukemia doesn’t usually form tumors, so imaging tests are not often helpful in making the diagnosis. When imaging tests are done in people with AML, it is most often to look for infections or other problems, rather than to look for the leukemia itself. In a few cases, imaging tests may be done to help determine the extent of the disease, if it is thought it may have spread beyond the bone marrow and blood.

**X-rays**

Routine chest x-rays may be done if a lung infection is suspected.

**Computed tomography (CT) scan**

This test can help show if any lymph nodes or organs in your body are enlarged. It isn’t usually needed to diagnose AML, but it may be done if your doctor suspects the leukemia is growing in an organ, like your spleen.
The CT scan uses x-rays to make detailed, cross-sectional images of your body. Unlike a regular x-ray, CT scans can show the detail in soft tissues (such as internal organs).

Before the test, you may be asked to drink a contrast solution and/or get an intravenous (IV) injection of a contrast dye that helps better outline abnormal areas in the body. You may need an IV line through which the contrast dye is injected. Injecting contrast dye can cause a feeling of flushing or warmth, in the face or elsewhere. Some people get hives or, rarely, more serious allergic reactions like trouble breathing and low blood pressure. Be sure to tell the doctor if you have any allergies or have ever had a reaction to any contrast material used for x-rays.

A CT scanner has been described as a large donut, with a narrow table that slides in and out of the middle opening. You need to lie still on the table while the scan is being done. CT scans take longer than regular x-rays, and you might feel a bit confined by the ring while the pictures are being taken.

**CT-guided needle biopsy:** In some cases, a CT can be used to guide a biopsy needle into a suspected abnormality, such as an abscess. For this procedure, you lie on the CT scanning table while the doctor moves a biopsy needle through the skin and toward the mass. CT scans are repeated until the needle is within the mass. A sample is then removed and sent to the lab to be looked at under a microscope.

**PET/CT:** Some machines combine the CT scan with a PET scan (PET/CT scan). For a PET scan, glucose (a form of sugar) containing a radioactive atom is injected into the blood. Because cancer cells in the body grow rapidly, they absorb large amounts of the radioactive sugar. A special camera can then create a picture of areas of radioactivity in the body. With a PET/CT scan, the doctor can compare areas of higher radioactivity on the PET scan with the more detailed appearance of that area on the CT.

**Magnetic resonance imaging (MRI) scan**

Like CT scans, MRI scans make detailed images of soft tissues in the body. But MRI scans use radio waves and strong magnets instead of x-rays. A contrast material is often injected into a vein before the scan to better see details. This contrast is not the same as the contrast used for CT scans, but allergic reactions can still occur.

MRI scans are very helpful in looking at the brain and spinal cord, but they are not usually needed in people with AML.

MRI scans take longer than CT scans – often up to an hour. You might have to lie inside a narrow tube, which is confining and can be distressing to some people. Newer, more open MRI machines may be another option. The MRI machine makes loud buzzing and clicking noises that you may find disturbing. Some places give you headphones or earplugs to help block this noise out.
**Ultrasound**

Ultrasound uses sound waves and their echoes to make pictures of internal organs or masses.

Ultrasound can be used to look at lymph nodes near the surface of the body or to look inside your abdomen for enlarged lymph nodes or organs such as the liver, spleen, and kidneys. (It can’t be used to look inside the chest because the ribs block the sound waves.) It is sometimes used to help guide a biopsy needle into an enlarged lymph node.

For this test, a small, microphone-like instrument called a *transducer* is usually placed on the skin over the area to be examined (the skin is first lubricated with gel). It gives off sound waves and picks up the echoes as they bounce off the organs. The echoes are converted by a computer into an image on a computer screen.

This is an easy test to have, and it uses no radiation. For most scans, you simply lie on a table, and a technician moves the transducer over the part of your body being looked at.

**How is acute myeloid leukemia classified?**

For most types of cancer, determining the stage (extent) of the cancer is very important. The stage is based on the size of the tumor and how far the cancer has spread. This can be helpful in predicting a person’s outlook and deciding on treatment.

Acute myeloid leukemia (AML), on the other hand, does not usually form tumors. It generally is in all of the bone marrow in the body and, in some cases, has spread to other organs, such as the liver and spleen. Therefore AML is not staged like most other cancers. The outlook for a person with AML depends instead on other information, such as the subtype of AML (determined by lab tests), the patient’s age, and other lab test results.

Knowing the subtype of AML can be very important, as it sometimes affects both a patient’s outlook and the best treatment. For example, the acute promyelocytic leukemia (APL) subtype is often treated using drugs that are different from those used for other subtypes of AML.

Two of the main systems that have been used to classify AML into subtypes are the French-American-British (FAB) classification and the newer World Health Organization (WHO) classification.

**The French-American-British (FAB) classification of AML**

In the 1970s, a group of French, American, and British leukemia experts divided AML into subtypes, M0 through M7, based on the type of cell from which the leukemia develops and how mature the cells are. This was based largely on how the leukemia cells looked under the microscope after routine staining.
<table>
<thead>
<tr>
<th>FAB subtype</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
<td>Undifferentiated acute myeloblastic leukemia</td>
</tr>
<tr>
<td>M1</td>
<td>Acute myeloblastic leukemia with minimal maturation</td>
</tr>
<tr>
<td>M2</td>
<td>Acute myeloblastic leukemia with maturation</td>
</tr>
<tr>
<td>M3</td>
<td>Acute promyelocytic leukemia (APL)</td>
</tr>
<tr>
<td>M4</td>
<td>Acute myelomonocytic leukemia</td>
</tr>
<tr>
<td>M4 eos</td>
<td>Acute myelomonocytic leukemia with eosinophilia</td>
</tr>
<tr>
<td>M5</td>
<td>Acute monocytic leukemia</td>
</tr>
<tr>
<td>M6</td>
<td>Acute erythroid leukemia</td>
</tr>
<tr>
<td>M7</td>
<td>Acute megakaryoblastic leukemia</td>
</tr>
</tbody>
</table>

Subtypes M0 through M5 all start in immature forms of white blood cells. M6 AML starts in very immature forms of red blood cells, while M7 AML starts in immature forms of cells that make platelets.

**World Health Organization (WHO) classification of AML**

The FAB classification system is useful and is still commonly used to group AML into subtypes. But it doesn’t take into account many of the factors that are now known to affect prognosis (outlook). The World Health Organization (WHO) has developed a newer system that includes some of these factors to try to better classify AML.

The WHO system divides AML into several groups:

**AML with certain genetic abnormalities**

- AML with a translocation between chromosomes 8 and 21
- AML with a translocation or inversion in chromosome 16
- AML with a translocation between chromosomes 9 and 11
- APL (M3) with a translocation between chromosomes 15 and 17
- AML with a translocation between chromosomes 6 and 9
• AML with a translocation or inversion in chromosome 3
• AML (megakaryoblastic) with a translocation between chromosomes 1 and 22

AML with myelodysplasia-related changes

AML related to previous chemotherapy or radiation

AML not otherwise specified (This includes cases of AML that don’t fall into one of the above groups, and is similar to the FAB classification.)

• AML with minimal differentiation (M0)
• AML without maturation (M1)
• AML with maturation (M2)
• Acute myelomonocytic leukemia (M4)
• Acute monocytic leukemia (M5)
• Acute erythroid leukemia (M6)
• Acute megakaryoblastic leukemia (M7)
• Acute basophilic leukemia
• Acute panmyelosis with fibrosis

Myeloid sarcoma (also known as granulocytic sarcoma or chloroma)

Myeloid proliferations related to Down syndrome

Undifferentiated and biphenotypic acute leukemias (leukemias that have both lymphocytic and myeloid features). Sometimes called ALL with myeloid markers, AML with lymphoid markers, or mixed phenotype acute leukemias.

Prognostic factors for acute myeloid leukemia

In recent years, research has focused on why some patients have a better chance to be cured than others. Differences among patients (or their leukemias) that affect response to treatment are called prognostic factors. Prognostic factors help doctors decide if people with a certain type of AML should get more or less treatment. Some of these include:

Chromosome abnormalities

AML cells can have many kinds of chromosome changes, some of which can affect a person’s prognosis. Those listed below are some of the most common, but there are many
others. Not all patients have these abnormalities. Patients without any of these usually have an outlook that is between favorable and unfavorable.

**Favorable abnormalities:**

- Translocation between chromosomes 8 and 21 (seen most often in patients with M2)
- Inversion of chromosome 16 (seen most often in patients with M4 eos) or a translocation between chromosome 16 and itself
- Translocation between chromosomes 15 and 17 (seen most often in patients with M3)

**Unfavorable abnormalities:**

- Deletion (loss) of part of chromosome 5 or 7 (no specific AML type)
- Translocation or inversion of chromosome 3
- Translocation between chromosomes 6 and 9
- Translocation between chromosomes 9 and 22
- Abnormalities of chromosome 11 (at the spot q23)
- Complex changes - those involving several chromosomes (no specific AML type)

**Gene mutations**

People whose leukemia cells have certain gene mutations may have a better or worse outlook.

For instance, about 1 patient out of 3 with AML has a mutation in the *FLT3* gene. These people tend to have a poorer outcome, but new drugs that target this abnormal gene are now being studied, which may lead to better outcomes.

On the other hand, people with changes in the *NPM1* gene (and no other abnormalities) seem to have a better prognosis than people without this change. Changes in the *CEBPA* gene are also linked to a better outcome.

In the coming years, doctors will use newer lab tests to learn more about the underlying genetic defects that cause AML and how they can be used to predict a patient’s prognosis. These genetic defects might also form the basis for treating these leukemias.

**Markers on the leukemia cells**

If the leukemia cells have the CD34 protein and/or the P-glycoprotein (*MDR1* gene product) on their surface, it is linked to a worse outcome.
Age

Older patients (over 60) generally don’t do as well as younger patients. Some of this may be because they are more likely to have unfavorable chromosome abnormalities. Older patients sometimes also have other medical conditions that can make it harder to treat them with more intense chemotherapy regimens.

White blood cell count

A high white blood cell count (>100,000) at the time of diagnosis is linked to a worse outlook.

Prior blood disorder leading to AML

Having a prior blood disorder such as a myelodysplastic syndrome is linked to a worse outcome.

Treatment-related AML

AML that develops after treatment for another cancer tends is linked to a worse outcome.

Infection

Having an active systemic (blood) infection at the time of diagnosis makes a poor outcome more likely.

Leukemia cells in the central nervous system

Leukemia that has spread to the area around the brain and spinal cord can be hard to treat, since most chemotherapy drugs can’t reach that area.

Status of acute myeloid leukemia after treatment

Not surprisingly, how well (and how quickly) the leukemia responds to treatment also affects long-term prognosis. Better responses have been linked with better long-term outcomes.

A remission (complete remission) is usually defined as having no evidence of disease after treatment. This means the bone marrow contains fewer than 5% blast cells, the blood cell counts are within normal limits, and there are no signs or symptoms of the disease. A molecular complete remission means there is no evidence of leukemia cells in the bone marrow, even when using very sensitive tests, such as PCR (polymerase chain reaction).

Minimal residual disease is a term used after treatment when leukemia cells can’t be found in the bone marrow using standard tests (such as looking at cells under a microscope), but more
sensitive tests (such as flow cytometry or PCR) find evidence that there are still leukemia cells in the bone marrow.

*Active disease* means that either there is evidence that the leukemia is still present during treatment or that the disease has come back after treatment (relapsed). For a patient to have relapsed, they must have more than 5% blast cells in their bone marrow.

**How is acute myeloid leukemia treated?**

*This information represents the views of the doctors and nurses serving on the American Cancer Society’s Cancer Information Database Editorial Board. These views are based on their interpretation of studies published in medical journals, as well as their own professional experience.*

*The treatment information in this document is not official policy of the Society and is not intended as medical advice to replace the expertise and judgment of your cancer care team. It is intended to help you and your family make informed decisions, together with your doctor.*

*Your doctor may have reasons for suggesting a treatment plan different from these general treatment options. Don’t hesitate to ask him or her questions about your treatment options.*

**General treatment information about acute myeloid leukemia**

As noted earlier, adult acute myeloid leukemia (AML) is not a single disease. It is really a group of related diseases, and patients with different subtypes of AML can have different outlooks and responses to treatment.

Once AML has been diagnosed, your cancer care team will discuss your treatment options with you. Your options may be affected by the AML subtype and lab tests of the leukemia cells, as well as certain other prognostic factors (described in the section “How is acute myeloid leukemia classified?”), as well as your overall state of health.

Several types of treatment may be used for people with AML. The main treatment for AML is chemotherapy, sometimes followed by a stem cell transplant. Other drugs (besides standard chemotherapy drugs) may also be used to treat people with acute promyelocytic leukemia (APL). Surgery and radiation therapy may be used in special circumstances.

The typical treatment approach for AML is different from the treatment approach for acute promyelocytic leukemia (APL).

It’s important to discuss all of your treatment options and their possible side effects with your doctors to help make the decision that best fits your needs. It’s also very important to ask questions if there is anything you’re not sure about. You can find some good questions to ask in the section “What should you ask your doctor about acute myeloid leukemia?”

In most cases AML can progress rapidly, so it is important to start treatment as soon as possible after the diagnosis is made.
Chemotherapy for acute myeloid leukemia

Chemotherapy (chemo) is the use of anti-cancer drugs that are injected into a vein, under the skin, or into the cerebrospinal fluid (CSF), or drugs that are taken by mouth to destroy or control cancer cells. Except when given into the CSF, these drugs enter the bloodstream and reach all areas of the body, making this treatment useful for cancers such as leukemia that spread throughout the body.

Chemotherapy is the main treatment for most people with acute myeloid leukemia (AML). Doctors give chemo in cycles, with each period of treatment followed by a rest period to allow the body time to recover. Chemo is often not recommended for patients in poor health, but advanced age by itself is not a barrier to getting chemo.

Treatment of AML is usually divided into 2 phases:

- **Induction** is the first phase of treatment. The goal is to clear the blood of leukemia cells (blasts) and to reduce the number of blasts in the bone marrow to normal.

- **Consolidation** is chemo given after the patient has recovered from induction. It is meant to kill the small number of leukemia cells that are still around but can’t be seen (because there are so few of them).

A third phase called **maintenance** involves giving a low dose of chemo for months or years after consolidation is finished. This is often used for the M3 subtype of AML (also known as acute promyelocytic leukemia, or APL), but it is rarely used for other types of AML.

The chemo drugs used most often to treat AML are cytarabine (cytosine arabinoside or ara-C) and the anthracycline drugs (such as daunorubicin (daunomycin), idarubicin, and mitoxantrone).

Some of the other chemo drugs that may be used to treat AML include:

- Cladribine (Leustatin®, 2-CdA)
- Fludarabine (Fludara®)
- Topotecan
- Etoposide (VP-16)
- 6-thioguanine (6-TG)
- Hydroxyurea (Hydrea®)
- Corticosteroid drugs, such as prednisone or dexamethasone (Decadron®)
- Methotrexate (MTX)
- 6-mercaptopurine (6-MP)
• Azacitidine (Vidaza®)
• Decitabine (Dacogen®)

Possible side effects

Chemo drugs attack cells that are dividing quickly, which is why they work against cancer cells. But other cells in the body, such as those in the bone marrow (where new blood cells are made), the lining of the mouth and intestines, and the hair follicles, also divide quickly. These cells are also likely to be affected by chemo, which can lead to side effects.

The side effects of chemo depend on the type and dose of drugs given and how long they are taken. These side effects can include:

• Hair loss
• Mouth sores
• Loss of appetite
• Nausea and vomiting
• Diarrhea or constipation

Chemo drugs also affect the normal cells in bone marrow, which can cause lowering of blood cell counts in AML patients. This can lead to:

• Increased risk of infections (from having too few normal white blood cells)
• Easy bruising or bleeding (from having too few blood platelets)
• Fatigue (from having too few red blood cells)

Most side effects last a short time and go away once treatment is finished. Low blood cell counts can last weeks, but then should return to normal. There are often ways to lessen these side effects. For example, drugs can be given to help prevent or reduce nausea and vomiting. Be sure to ask about medicines to help reduce side effects, and let your doctor or nurse know when you do have side effects so they can be managed effectively.

Drugs known as growth factors, such as G-CSF (filgrastim, Neupogen®) and GM-CSF (sargramostim, Leukine®), are sometimes given to increase the white blood cell counts after chemo, to reduce the chance of infection. However, it’s not clear if they have an effect on treatment success.

If your white blood cell counts are very low during treatment, you can help reduce your risk of infection by carefully avoiding exposure to germs. During this time, your doctor may tell you to:
• Wash your hands often.
• Avoid fresh, uncooked fruits and vegetables and other foods that might carry germs.
• Avoid fresh flowers and plants because they may carry mold.
• Make sure other people wash their hands before they come in contact with you.
• Avoid large crowds and people who are sick.

You may get antibiotics before there are signs of infection or at the earliest sign that an infection may be developing (such as a fever). You may also get drugs that help prevent viral and fungal infections.

Some of the most serious side effects of chemo are caused by low white blood cell counts. Decisions about when a patient can leave the hospital are often influenced by his or her blood counts. Some people find it helpful to keep track of their counts. If you are interested in this, ask your doctor or nurse about your blood cell counts and what these numbers mean.

If your platelet counts are low, you may be given drugs or platelet transfusions to help prevent bleeding. Likewise, shortness of breath and extreme fatigue caused by low red blood cell counts may be treated with drugs or with red blood cell transfusions.

Certain drugs have some specific possible side effects. For example, when used at high doses, cytarabine can cause certain problems, including dryness in the eyes and effects on certain parts of the brain, which can lead to problems with coordination or balance. The drug dose may need to be reduced or stopped altogether if these side effects appear.

Anthracyclines can damage the heart, so they might not be used in someone who already has heart problems.

Other organs that could be damaged by chemo drugs include the kidneys, liver, testicles, ovaries, and lungs. Doctors and nurses carefully monitor treatment to limit the risk of these side effects as much as possible.

If serious side effects occur, the chemo may have to be reduced or stopped, at least for a short time. Careful monitoring and adjustment of drug doses are important because some side effects can be permanent.

**Tumor lysis syndrome** is another possible side effect of chemo. This can occur in patients who have large numbers of leukemia cells in the body, so it mainly occurs in patients during the induction phase of treatment. When chemo kills these cells, they break open and release their contents into the bloodstream. This can overwhelm the kidneys, which aren’t able to get rid of all of these substances at once. Excess amounts of certain minerals can also affect the heart and nervous system. This can be prevented by giving extra fluids during treatment and by giving certain drugs, such as bicarbonate, allopurinol, and rasburicase, which help the body get rid of these substances.
For more about chemo and its side effects, see the Chemotherapy section of our website, or our document *A Guide to Chemotherapy.*

**Other drugs for acute myeloid leukemia**

Chemotherapy is the main treatment for most types of acute myeloid leukemia (AML). But acute promyelocytic leukemia (APL or AML M3) is different from other types of AML in some important ways.

The leukemia cells (or blasts) in APL contain proteins that when released into the bloodstream can cause the blood to clot in an out-of-control way. This can lead to problems not only with blood clots, but also with severe bleeding. In the past, when regular chemotherapy (chemo) drugs were used alone to kill these cells, these proteins were released into the bloodstream. Patients sometimes died from complications from the out-of-control clotting or bleeding.

Experts realized that the leukemia cells in APL have a specific gene change that makes them sensitive to certain drugs that aren’t like regular chemo drugs. These drugs signal the blasts to transform into mature myeloid cells. This process is known as differentiation, and these drugs are called differentiation agents. Since the blasts don’t die, they don’t release the harmful proteins into the blood, which helps keep the clotting process from getting out of control.

There are 2 drugs that are used for this in APL: all-trans-retinoic acid (ATRA, tretinoin, or Vesanoid®) and arsenic trioxide (ATO, Trisenox®).

**ATRA**

ATRA is a form of vitamin A that is often part of the initial (induction) treatment of APL. It is often given along with chemo. It can also be given with arsenic trioxide for the initial treatment of APL, in which case no regular chemo drugs are given. If ATRA is part of the initial treatment for APL, it is often used for some time after to help keep the leukemia from coming back. For the consolidation phase of treatment, it may be used with chemo, with arsenic trioxide, or with both chemo and arsenic trioxide. For longer-term maintenance, ATRA might be used by itself or along with chemo.

ATRA can have side effects similar to those seen if you take too much vitamin A. Symptoms can include headache, fever, dry skin and mouth, skin rash, swollen feet, sores in the mouth or throat, itching, and irritated eyes. It can also cause blood lipid levels (like cholesterol and triglycerides) to go up. Often blood liver tests become abnormal. These side effects often go away when the drug is stopped.
Arsenic trioxide

Arsenic trioxide (ATO) is a form of arsenic, which can be a poison if given in high doses. But doctors found that it can act in a way similar to ATRA in patients with APL. It can be given with ATRA as the first treatment, but it is also helpful in treating patients whose APL comes back after treatment with ATRA plus chemo. In these patients, ATO is given without chemo.

Most side effects of ATO are mild and can include fatigue (tiredness), nausea, vomiting, diarrhea, abdominal (belly) pain, and nerve damage (called neuropathy) leading to numbness and tingling in the hands and feet. ATO can also cause problems with heart rhythm, which can be serious. Your doctor may check your heart rhythm with an EKG often (even daily) while you are getting this drug.

Differentiation syndrome

The most important side effect of either of these drugs is known as differentiation syndrome (previously called retinoic acid syndrome). This occurs when the leukemia cells release certain chemicals into the blood. It is most often seen during the first cycle of treatment.

Symptoms can include fever, breathing problems due to fluid buildup in the lungs and around the heart, low blood pressure, kidney damage, and severe fluid buildup elsewhere in the body. It can often be treated by stopping the drugs for a while and giving a steroid such as dexamethasone.

Surgery for acute myeloid leukemia

Surgery has a very limited role in the treatment of acute myeloid leukemia (AML). Because leukemia cells are spread widely throughout the bone marrow and blood, it’s not possible to cure this type of cancer with surgery. Surgery rarely has any role even in the diagnosis of AML, since this can usually be done with a bone marrow aspirate and biopsy. On rare occasions, an isolated tumor of leukemia cells (known as a granulocytic sarcoma or a chloroma) may be treated with surgery.

Often before chemotherapy is about to start, a minor type of surgery is used to place a small flexible tube, called a central venous catheter (CVC) or venous access device (VAD), into a large vein in the chest. This may be done by a surgeon in the operating room, or by a special type of radiologist. The end of the tube stays just under the skin or sticks out in the chest area or upper arm. The VAD is left in place during treatment to give intravenous (IV) drugs, such as chemotherapy, and to take blood samples for tests. This lowers the number of needle sticks needed during treatment. If you have a VAD, it is very important to learn how to care for it to keep it from getting infected.
Radiation therapy for acute myeloid leukemia

Radiation therapy uses high-energy radiation to kill cancer cells. It is usually not part of the main treatment for people with acute myeloid leukemia (AML), but there are a few instances in which it may be used:

- Radiation is sometimes used to treat leukemia that has spread to the brain and spinal fluid or to the testicles.
- Radiation to the whole body is often an important part of treatment before a stem cell transplant (see the section “Stem cell transplant for acute myeloid leukemia”).
- It is used (rarely) to help shrink a tumor if it is pressing on the trachea (windpipe) and causing breathing problems. But chemotherapy is often used instead, as it often works more quickly.
- Radiation can be used to reduce pain in an area of bone that is invaded by leukemia, if chemotherapy hasn’t helped.

Before your treatment starts, the radiation team will take careful measurements to determine the correct angles for aiming the radiation beams and the proper dose of radiation. The type of radiation therapy used to treat AML is called external beam radiation. The treatment is much like getting an x-ray, but the radiation is much stronger. The procedure itself is painless. The number of treatments you get depends on the reason radiation therapy is being used. Each treatment lasts only a few minutes, although the setup time – getting you into place for treatment – usually takes longer.

The possible side effects of radiation therapy depend on where the radiation is aimed. Sunburn-like skin changes in the treated area are possible. Radiation to the head and neck area can lead to mouth sores and trouble swallowing. Radiation to the abdomen can cause nausea, vomiting, or diarrhea. Radiation can lower blood counts, leading to fatigue (from low red blood cell counts), bleeding or bruising (from low platelet counts), and an increased risk of infection (from low white blood cell counts).

To learn more about radiation therapy, see the Radiation Therapy section of our website, or our document Understanding Radiation Therapy: A Guide for Patients and Families.

Stem cell transplant for acute myeloid leukemia

The doses of chemotherapy drugs that doctors can give are limited by the serious side effects they can cause. Even though higher doses of these drugs might kill more cancer cells, they can’t be given because they could severely damage the bone marrow, which is where new blood cells are formed. This could lead to life-threatening infections, bleeding, and other problems due to low blood cell counts.
Doctors can sometimes use a stem cell transplant (SCT) to give higher doses of chemotherapy (sometimes combined with radiation therapy) than could normally be given. After the treatment is finished, the patient gets an infusion of blood-forming stem cells to restore their bone marrow.

The blood-forming stem cells used for a transplant can come either from the blood or from the bone marrow. Sometimes stem cells from a baby’s umbilical cord blood are used.

**Types of transplants**

The 2 main types of stem cell transplants differ based on whom the blood-forming stem cells come from.

**Allogeneic stem cell transplant**

This is the most common type of SCT used to treat acute myeloid leukemia (AML). In an allogeneic SCT, the stem cells come from someone other than the patient – usually a donor whose tissue type (also known as the HLA type) closely matches the patient’s. Tissue type is based on certain substances on the surface of cells in the body. These substances can cause the immune system to react against the cells. Therefore, the closer a tissue “match” is between the donor and the recipient, the better the chance the transplanted cells will “take” and begin making new blood cells.

The best donor is often a close relative, such as a brother or sister, if they are a good match. If no close relatives match, stem cells might be available from a matched unrelated donor (MUD), an unrelated volunteer whose tissue type matches that of the patient. But the use of stem cells from a MUD is linked to more complications. Sometimes umbilical cord stem cells are used. These stem cells come from blood drained from the umbilical cord and placenta after a baby is born and the umbilical cord is cut.

In AML, using an allogeneic SCT is preferred over an autologous SCT (see below) because leukemia is a disease of the blood and bone marrow, so giving the patient his or her own cells back may mean giving them back some leukemia cells as well. Donor cells are also helpful because of the “graft-versus-leukemia” effect. When the donor immune cells are infused into the body, they may recognize any remaining leukemia cells as being foreign to them and attack them. This effect doesn’t happen with autologous stem cell transplants.

Allogeneic transplants can have serious risks and side effects, so patients typically need to be younger and relatively healthy to be good candidates. Another challenge is that it can sometimes be difficult to find a matched donor.

One of the most serious complications of allogeneic SCTs is known as *graft-versus-host disease* (GVHD). It happens when the patient’s immune system is taken over by that of the donor. When this happens, the donor immune system may consider the patient’s own body tissues to be foreign and attacks them.
Symptoms can include severe skin rashes, itching, mouth sores (which can affect eating), nausea, and severe diarrhea. Liver damage can cause yellowing of the skin and eyes (jaundice). The lungs can also be damaged. The patient may also become easily fatigued and develop muscle aches. Sometimes GVHD can become disabling, and if it is severe enough, it can be life-threatening. Drugs that affect the immune system may be given to try to control it.

**Non-myeloablative transplant (mini-transplant):** Many older people can’t tolerate a standard allogeneic transplant that uses high doses of chemo. Some may still be able to get a non-myeloablative transplant (also known as a mini-transplant or reduced-intensity transplant), where they get lower doses of chemo and radiation that don’t completely destroy the cells in their bone marrow. They then get the allogeneic (donor) stem cells. These cells enter the body and establish a new immune system, which sees the leukemia cells as foreign and attacks them (a “graft-versus-leukemia” effect).

A non-myeloablative transplant can still sometimes work with much less toxicity. In fact, a patient can receive the transplant as an outpatient. The major complication is graft-versus-host disease (described below).

Many doctors still consider this an experimental procedure for AML, and studies are under way to determine how useful it may be.

**Autologous stem cell transplant**

In an autologous transplant, a patient’s own stem cells are removed from his or her bone marrow or blood. They are frozen and stored while the person gets treatment (high-dose chemotherapy and/or radiation). A process called purging may be used to try to remove any leukemia cells in the samples. The stem cells are then put back (reinfused) into the patient’s blood after treatment.

Autologous transplants are sometimes used for people with AML who are in remission after initial treatment and who don’t have a matched donor for an allogeneic transplant. Some doctors feel that it is better than standard “consolidation” chemotherapy (see the section “Typical treatment of acute myeloid leukemia”) for these people, but not all doctors agree with this.

Autologous transplants are generally easier to tolerate than allogeneic transplants, because the patient is getting his or her own cells back, which lowers the risk of some complications. But the high-dose chemo can still cause major side effects. This type of transplant can be done in any otherwise healthy person, although very old patients might not be suitable.

One problem with autologous transplants is that it’s hard to separate normal stem cells from leukemia cells in the bone marrow or blood samples. Even after purging (treating the stem cells in the lab to try to kill or remove any remaining leukemia cells), there is the risk of returning some leukemia cells with the stem cell transplant.
The transplant procedure

Blood-forming stem cells from the bone marrow or blood are collected, frozen, and stored. The patient gets high-dose chemo and sometimes also radiation treatment to the entire body. (Radiation shields are used to protect the lungs, heart, and kidneys from damage during radiation therapy.)

These treatments are meant to destroy any cancer cells in the body. They also kill the normal cells of the bone marrow and the immune system. After these treatments, the frozen stem cells are thawed and given as a blood transfusion. The stem cells settle into the patient’s bone marrow over the next several days and start to grow and make new blood cells.

In an allogeneic SCT, the person getting the transplant is given drugs to keep the new immune system in check. For the next few weeks the patient will get regular blood tests and supportive therapies as needed, which might include antibiotics, red blood cell or platelet transfusions, other medicines, and help with nutrition.

Usually within a couple of weeks after the stem cells have been infused, they begin making new white blood cells. This is followed by new platelets and, several weeks later, new red blood cells.

Patients need to stay in the hospital until their neutrophil count (often called the ANC) rises to a safer level (at least 500, but sometimes 1,500 is the target). Other factors also affect how long a person needs to stay in the hospital, like the type of transplant, the presence of an infection or other complications, and the ability of the patient to be followed-up in the outpatient clinic. After discharge from the hospital, the patient is seen in the outpatient clinic for several weeks, often daily. Because platelet counts take longer to return to a safe level, patients may get platelet transfusions as an outpatient.

Practical points

A stem cell transplant is a complex treatment that can sometimes cause life-threatening side effects. If the doctors think you might benefit from a transplant, it should be done at a hospital where the staff has experience with the procedure and with managing the recovery phase. Some stem cell transplant programs might not have experience in certain types of transplants, especially transplants from unrelated donors.

SCT is very expensive (costing well over $100,000) and often requires a lengthy hospital stay. Because some types of SCT may be viewed as experimental by insurance companies, they may not pay for the procedure. It is important to find out what your insurer will cover before deciding on a transplant to get an idea of what you might have to pay.

Possible side effects

Side effects from SCT are generally divided into early and long-term effects.
Early or short-term effects: The early complications and side effects are basically the same as those caused by any other type of chemotherapy (see the section “Chemotherapy for acute myeloid leukemia”), although they tend to be more severe. They can include low blood cell counts (with fatigue and an increased risk of infection and bleeding), nausea, vomiting, loss of appetite, mouth sores, and hair loss.

One of the most common and serious short-term effects is the increased risk of infection. Antibiotics are often given to try to prevent this from happening. Other side effects, like low red blood cell and platelet counts, may require blood product transfusions or other treatments.

A possible serious side effect of allogeneic transplants is graft-versus-host disease, which is described above.

Long-term side effects: Some complications and side effects can remain for a long time or might not occur until months or years after the transplant. These include:

- Chronic graft-versus-host disease (only in allogeneic transplants)
- Loss of fertility
- Damage to the lungs, causing shortness of breath
- Damage to the thyroid gland, causing problems with metabolism
- Cataracts (damage to the lens of the eye that can affect vision)
- Bone damage called *aseptic necrosis* (where the bone dies because of poor blood supply). If damage is severe, the patient might need to have part of the bone and the joint replaced.
- Development of another cancer years later

For more on stem cell transplants, see *Stem Cell Transplant (Peripheral Blood, Bone Marrow, and Cord Blood Transplants).*

Clinical trials for acute myeloid leukemia

You may have had to make a lot of decisions since you’ve been told you have acute myeloid leukemia (AML). One of the most important decisions you will make is choosing which treatment is best for you. You may have heard about clinical trials being done for AML. Or maybe someone on your health care team has mentioned a clinical trial to you.

Clinical trials are carefully controlled research studies that are done with patients who volunteer for them. They are done to learn more about promising new treatments or procedures.
Clinical trials are one way to get state-of-the-art cancer treatment. Sometimes they may be the only way to get some newer treatments. They are also the best way for doctors to learn better methods to treat cancer. Still, they are not right for everyone.

If you would like to learn more about clinical trials that might be right for you, start by asking your doctor if your clinic or hospital conducts clinical trials. You can also call our clinical trials matching service for a list of studies that might meet your medical needs. You can reach this service at 1-800-303-5691 or on our website at www.cancer.org/clinicaltrials. You can also get a list of current clinical trials by calling the National Cancer Institute (NCI) at 1-800-4-CANCER (1-800-422-6237) or by visiting the NCI clinical trials website at www.cancer.gov/clinicaltrials.

You will need to meet certain requirements to take part in any clinical trial. But if you do qualify for a clinical trial, it’s up to you whether or not to enter (enroll in) it.

To learn more about clinical trials, see Clinical Trials: What You Need to Know.

Complementary and alternative therapies for acute myeloid leukemia

You might hear about ways to treat your leukemia or relieve symptoms that your doctor hasn’t mentioned. Everyone from friends and family to social media groups and websites might offer ideas for what might help you. These methods can include vitamins, herbs, and special diets, or other methods such as acupuncture or massage, to name a few.

What exactly are complementary and alternative therapies?

Not everyone uses these terms the same way, and they are used to refer to many different methods, so it can be confusing. We use complementary to refer to treatments that are used along with your regular medical care. Alternative treatments are used instead of a doctor’s medical treatment.

Complementary methods: Most complementary treatment methods are not offered as cures for cancer. Mainly, they are used to help you feel better. Some methods that are used along with regular treatment are meditation to reduce stress, acupuncture to help relieve pain, or peppermint tea to relieve nausea. Some complementary methods are known to help, while others have not been tested. Some have been proven not to be helpful, and a few have even been found to be harmful.

Alternative treatments: Alternative treatments may be offered as cancer cures. These treatments have not been proven safe and effective in clinical trials. Some of these methods may pose danger, or have life-threatening side effects. But the biggest danger in most cases is that you may lose the chance to be helped by standard medical treatment. Delaying or interrupting your medical treatments might give the cancer more time to grow and make it less likely that treatment will help.
Finding out more

It’s easy to see why people with cancer think about alternative methods. You want to do all you can to fight the cancer, and the idea of a treatment with no side effects sounds great. Sometimes medical treatments like chemotherapy can be hard to take, or they may no longer be working. But the truth is that most alternative methods have not been tested and proven to work in treating cancer.

As you consider your options, look for “red flags” that might suggest fraud. Does the method promise to cure all or most cancers? Are you told not to have regular medical treatments? Is the treatment a “secret” that requires you to visit certain providers or travel to another country? Also be sure to talk to your cancer care team about any method you are thinking about using.

You can find more tips on what to look for and how to make these decisions in the Complementary and Alternative Medicine section of our website.

The choice is yours

Decisions about how to treat or manage your leukemia are always yours to make. If you want to use a non-standard treatment, learn all you can about the method and talk to your doctor about it. With good information and the support of your health care team, you may be able to safely use the methods that can help you while avoiding those that could be harmful.

Typical treatment of most types of acute myeloid leukemia (except acute promyelocytic M3)

Treatment of most cases of acute myeloid leukemia (AML) is usually divided into 2 chemotherapy (chemo) phases:

- Remission induction (often just called induction)
- Consolidation (post-remission therapy)

Treatment usually needs to start as quickly as possible after the diagnosis because AML can progress very quickly. Sometimes another type of treatment needs to be started even before the chemo has had a chance to work.

Treating leukostasis

Some people with AML have very high numbers of leukemia cells in their blood when they are diagnosed, which can cause problems with normal circulation. This is called leukostasis and was discussed in the section “Signs and symptoms of acute myeloid leukemia.” Chemo can take a few days to lower the number of leukemia cells in the blood. In the meantime, leukapheresis (sometimes just called pheresis) might be used before chemo.
For this procedure, the patient’s blood is passed through a special machine that removes white blood cells (including leukemia cells) and returns the rest of the blood to the patient. Two intravenous (IV) lines are required – the blood is removed through one IV, goes through the machine, and then is returned to the patient through the other IV. Sometimes, a single large catheter is placed in a vein in the neck or under the collar bone for the pheresis – instead of using IV lines in both arms. This type of catheter is called a **central line** and has both IVs built in.

This treatment lowers blood counts right away. The effect is only for a short time, but it may help until the chemo has a chance to work.

**Induction**

This first part of treatment is aimed at getting rid of as many leukemia cells as possible. How intense the treatment is can depend on a person’s age and health. Doctors often give the most intensive chemo to people under the age of 60. Some older patients in good health may benefit from similar or slightly less intensive treatment.

People who are much older or are in poor health might not do well with intensive chemo. Treatment of these patients is discussed below in “Treating frail, older adults.”

Age, health, and other factors clearly need to be taken into account when considering treatment options. Doctors are also trying to determine whether people with certain gene or chromosome changes are more likely to benefit from more intensive treatment.

In younger patients, such as those under 60, induction often involves treatment with 2 chemo drugs, cytarabine (ara-C) and an anthracycline drug such as daunorubicin (daunomycin) or idarubicin. Sometimes a third drug, cladribine (Leustatin, 2-CdA), is given as well. The chemo is usually given in the hospital and lasts about a week.

Patients with poor heart function can’t be treated with anthracyclines, so they may be treated with another chemo drug, such as fludarabine (Fludara) or topotecan.

In rare cases where the leukemia has spread to the brain or spinal cord, chemo may also be given into the cerebrospinal fluid (CSF). Radiation therapy might be used as well.

Induction destroys most of the normal bone marrow cells as well as the leukemia cells. Most patients develop dangerously low blood counts at this time, and may be very ill. Most patients need antibiotics and blood product transfusions. Drugs to raise white blood cell counts may also be used. Blood counts tend to stay low for a few weeks. Usually, the patient stays in the hospital during this time.

About 1 or 2 weeks after chemo is done, the doctor will check a bone marrow biopsy. It should show few bone marrow cells (**hypocellular** bone marrow) and only a small portion of blasts. If the biopsy shows that there are still leukemia cells in the bone marrow, more chemo may be given. Sometimes a stem cell transplant is recommended at this point. If it isn’t clear
on the bone marrow biopsy whether the leukemia is still there, another bone marrow biopsy may be done again in about a week.

Over the next few weeks, normal bone marrow cells will return and start making new blood cells. The doctor may check other bone marrow biopsies during this time. When the blood cell counts recover, the doctor will again check cells in a bone marrow sample to see if the leukemia is in remission (blasts make up no more than 5% of the bone marrow).

Remission induction usually does not destroy all the leukemia cells, and a small number often remain. Without consolidation treatment, the leukemia is likely to return within several months.

**Consolidation (post-remission therapy)**

Induction is considered successful if remission is achieved. Further treatment is then given to try to destroy any remaining leukemia cells and help prevent a relapse. This is called *consolidation*.

For younger patients, the main options for consolidation therapy are:

- Several cycles of high-dose cytarabine (ara-C) chemo (sometimes known as *HiDAC*)
- Allogeneic (donor) stem cell transplant
- Autologous stem cell transplant

Consolidation chemo differs from induction therapy in that usually only cytarabine is used. The drug is given at very high doses, typically over 5 days. This is repeated about every 4 weeks, usually for a total of 3 or 4 cycles. Another approach after successful induction therapy is to give very high doses of chemo followed by either an allogeneic (from a donor) or autologous (patient’s own) stem cell transplant. Stem cell transplants have been found to reduce the risk of leukemia coming back more than standard chemo, but they are also more likely to have serious complications, including an increased risk of death from treatment.

Older patients or those in poor health may not be able to tolerate such intensive consolidation treatment. Often, giving them more intensive therapy raises the risk of serious side effects (including treatment-related death) without providing much more of a benefit. These patients may be treated with:

- 1 or 2 cycles of higher dose cytarabine (usually not quite as high as in younger patients)
- 1 or 2 cycles of standard dose cytarabine, possibly along with idarubicin, daunorubicin, or mitoxantrone
- Non-myeloablative stem cell transplant (mini-transplant)
It is not always clear which treatment option is best for consolidation. Each has pros and cons. Doctors look at several different factors when recommending what type of therapy a patient should get. These include:

- **How many courses (cycles) of chemo it took to bring about a remission.** If it took more than one course, some doctors recommend that the patient get a more intensive program, which might include a stem cell transplant.

- **The availability of a brother, sister, or an unrelated donor who matches the patient’s tissue type.** If a close enough tissue match is found, an allogeneic (donor) stem cell transplant may be an option, especially for younger patients.

- **The potential of collecting leukemia-free bone marrow cells from the patient.** If lab tests show that a patient is in remission, collecting stem cells from the patient’s bone marrow or blood for an autologous stem cell transplant may be an option. Stem cells collected from the patient would be purged (treated in the lab to try to remove or kill any remaining leukemia cells) to lower the chances of relapse.

- **The presence of one or more adverse prognostic factors,** such as certain gene or chromosome changes, a very high initial white blood cell count, AML that develops from a previous blood disorder or after treatment for an earlier cancer, or spread to the central nervous system. These factors might lead doctors to recommend more aggressive therapy, such as a stem cell transplant. On the other hand, for people with good prognostic factors, such as favorable gene or chromosome changes, many doctors might advise holding off on a stem cell transplant unless the disease recurs.

- **The patient’s age.** Older patients may not be able to tolerate some of the severe side effects that can occur with high-dose chemo or stem cell transplants.

- **The patient’s wishes.** There are many issues that revolve around quality of life that must be discussed. An important issue is the higher chance of early death from high-dose chemo or a stem cell transplant. This and other issues must be discussed between the patient and the doctor.

Stem cell transplants are intensive treatments with real risks of serious complications, including death, and their exact role in treating AML is not always clear. Some doctors feel that if the patient is healthy enough to withstand the procedure and a compatible donor is available, an allogeneic transplant offers the best chance for long-term survival. Others feel that studies have not yet shown this conclusively, and that in some cases a transplant should be reserved in case the leukemia comes back after standard treatment. Still others feel that stem cell transplants should be given if the leukemia is likely to come back based on certain gene or chromosome changes. Research in this area continues to see which AML patients get the most benefit from stem cell transplant and what is the best transplant procedure.
Treating frail, older adults

Treatment of AML in people under 60 is fairly standard. It involves cycles of intensive chemo, sometimes along with a stem cell transplant (as discussed above). Many patients older than 60 are healthy enough to be treated in the same way, although sometimes the chemo may be less intense. People who are much older or are in poor health may not be able to tolerate this intense treatment. In fact, intense chemo could actually shorten their lives.

In some cases, doctors may recommend low-intensity chemo with a low dose of cytarabine given in cycles. Sometimes, these patients may be treated with other chemo drugs like azacitidine (Vidaza) or decitabine (Dacogen). These drugs aren’t approved to treat AML, but still may be helpful. In some cases, this may induce remission. In others, it may control the leukemia for a time. Treatment of these patients is often not divided into induction and consolidation phases, but it may be given every so often as long as it seems helpful.

Some patients decide against chemo and other drugs and instead choose supportive care. This focuses on treating any symptoms or complications that arise and keeping the person as comfortable as possible.

Treatment of acute promyelocytic (M3) leukemia

Early diagnosis and treatment of acute promyelocytic leukemia (APL), the M3 subtype of acute myeloid leukemia (AML), is important because patients with APL can develop serious blood-clotting or bleeding problems. This is less often a problem now that treatment includes differentiating drugs like all-trans-retinoic acid (ATRA). Other treatments might include chemotherapy and transfusions of platelets or other blood products.

Induction

The treatment of most cases of APL differs from usual AML treatment. Initial treatment includes the non-chemothrapy drug all-trans-retinoic acid (ATRA), which is most often combined with an anthracycline chemotherapy (chemo) drug (daunorubicin or idarubicin), sometimes also with the chemo drug cytarabine (ara-c).

Another option is to give ATRA plus another differentiating drug called arsenic trioxide (Trisenox). This is often used in patients who can’t tolerate an anthracycline drug, but it’s an option for other patients as well.

Consolidation

As with other subtypes of AML, patients with APL then receive post-remission treatment. What drugs are used depends on what was given for induction. Some of the options include:

- An anthracycline along with ATRA for a few cycles (sometimes different anthracyclines are used in different cycles)
• An anthracycline plus cytarabine for at least 2 cycles
• Arsenic trioxide for 2 cycles (over about 2½ months), then ATRA plus an anthracycline for 2 cycles
• ATRA plus arsenic trioxide for several cycles

**Maintenance**

For some patients, consolidation may be followed by maintenance therapy with ATRA for at least a year. Sometimes low doses of the chemo drugs 6-mercaptopurine (6-MP) and methotrexate are given as well.

**Treatment response rates for acute myeloid leukemia**

**For most types of acute myeloid leukemia**

About 2 out of 3 acute myeloid leukemia (AML) patients who get standard induction chemotherapy (chemo) with daunorubicin and cytarabine go into remission. This usually means the bone marrow contains fewer than 5% blast cells, the blood cell counts are within normal limits, and there are no signs or symptoms of the disease. The actual chance of remission depends to a large part on a person’s specific prognostic factors, such as age or the presence of certain gene or chromosome changes.

If remission is achieved, patients may then get more chemo (consolidation). Up to half of patients that get this go into long-term remission (and may be cured). But this number is also affected by prognostic factors, such as a person’s age and whether the leukemia cells have certain gene or chromosome changes. Using an allogeneic stem cell transplant as consolidation has a higher success rate, but it also has a higher risk of death as a complication.

Older patients generally don’t do as well as those younger than 60. They often have trouble tolerating intensive treatment and often have chromosome changes in their leukemia cells that are linked to a poorer outlook. About half of these patients go into remission after initial treatment.

**For acute promyelocytic leukemia (APL)**

More than 90% of patients with APL go into remission with standard induction treatment. With consolidation and maintenance, about 70% to 90% of patients with APL are successfully treated long-term.
What if acute myeloid leukemia doesn’t respond or comes back after treatment?

**For most types of acute myeloid leukemia**

If acute myeloid leukemia (AML) doesn’t go away with the first treatment, newer drugs or more intensive doses of chemotherapy (chemo) drugs may be tried, if they can be tolerated. A stem cell transplant may be tried in younger patients if a suitable stem cell donor can be found. Clinical trials of new treatment approaches may also be an option.

If the leukemia went away and has now come back, the treatment options depend on the patient’s age and health, and on how long the leukemia was in remission. AML most often recurs in the bone marrow and blood. The brain or cerebrospinal fluid (CSF) rarely will be the first place it recurs, but if it does, it is often treated with chemo given directly into the CSF (during a lumbar puncture/spinal tap).

For those whose remission lasted longer than 12 months, it is sometimes possible to put the leukemia into remission again with more chemo, although this is not likely to be long-lasting. For younger patients (generally those younger than 60), most doctors would then advise a stem cell transplant if a suitable donor can be found. Clinical trials of new treatment approaches may also be considered.

If AML comes back sooner than 12 months, most doctors will advise a stem cell transplant for younger patients, if possible. Taking part in a clinical trial is another option.

If the leukemia keeps coming back or doesn’t go away, further chemo treatment will probably not be very helpful. If a stem cell transplant is not an option, a patient may want to consider taking part in a clinical trial of newer treatments.

**For acute promyelocytic leukemia**

For patients with acute promyelocytic leukemia (APL) who don’t respond to initial treatment with chemo plus ATRA or who relapse, arsenic trioxide (Trisenox) is often very effective. A stem cell transplant may be another option if a donor can be found.

If treatment with arsenic trioxide achieves a remission, further courses of this drug may be given. An autologous stem cell transplant may also be an option. If a second remission is not achieved, treatment options may include an allogeneic stem cell transplant or taking part in a clinical trial.

**Palliative treatment**

If further treatment or a clinical trial is not an option, the focus of treatment may shift to controlling symptoms caused by the leukemia, rather than trying to cure the leukemia. This is
called palliative treatment or supportive care. For example, the doctor may advise less intensive chemo to try to slow the leukemia growth instead of trying to cure it.

As the leukemia grows in the bone marrow it may cause pain. It’s important that you be as comfortable as possible. Treatments that may be helpful include radiation therapy and appropriate pain-relieving medicines. If medicines such as aspirin and ibuprofen don’t help with the pain, stronger opioid medicines such as morphine are likely to be helpful. Some people may worry about taking stronger drugs for fear of being sleepy all the time or becoming addicted to them. But many people get very effective pain relief from these medicines without serious side effects. It’s very important to let your cancer care team know if you are having pain so that it can be treated.

Other common symptoms from leukemia are low blood counts and fatigue. Medicines or blood transfusions may be needed to help correct these problems. Nausea and loss of appetite can be treated with medicines and high-calorie food supplements. Infections that occur may be treated with antibiotics.

What should you ask your doctor about acute myeloid leukemia?

It is important to have open and honest communications with your doctor about your condition. Ask about anything you don’t understand or want to know more about. For instance, consider these questions:

- What kind of acute myeloid leukemia (AML) do I have?
- Are there any specific factors that might affect my prognosis?
- Do I need other tests before we can decide on treatment?
- Do I need to see any other doctors?
- How much experience do you and this medical center have treating this type of cancer?
- Should I get a second opinion?
- What are my treatment choices?
- Should we consider a stem cell transplant? When?
- Which treatment do you recommend, and why?
- What should I do to be ready for treatment?
- How long will treatment last? What will it be like? Where will it be done?
- What are the risks and side effects of treatment?
• How will treatment affect my daily activities?
• What is my prognosis?
• What will we do if the treatment doesn’t work or if the leukemia comes back?
• What type of follow-up will I need after treatment?

Be sure to write down any questions you have that are not on this list. For instance, you might want specific information about expected recovery times. Or you may want to ask about clinical trials for which you may qualify. Taking another person and/or a tape recorder to your appointments can be helpful.

Keep in mind, too, that doctors aren’t the only ones who can give you information. Other health care professionals, such as nurses and social workers, might be able to answer some of your questions. You can find out more about speaking with your health care team in Talking With Your Doctor.

What happens after treatment for acute myeloid leukemia?

For some people with acute myeloid leukemia (AML), treatment can destroy the leukemia cells. Completing treatment can be both stressful and exciting. You may be relieved to finish treatment, but find it hard not to worry about the leukemia coming back. (When leukemia comes back after treatment, it is called recurrence.) This is a very common concern in people who have had cancer.

It may take a while before your fears lessen. But it may help to know that many leukemia survivors have learned to live with this uncertainty and are leading full lives. Our document Living With Uncertainty: The Fear of Cancer Recurrence, talks more about this.

For other people, the leukemia may never go away completely. These people may get regular treatments with chemotherapy or other therapies to try to help keep the leukemia under control and help relieve symptoms from it. Learning to live with leukemia that does not go away can be difficult and very stressful. It has its own type of uncertainty. Our document When Cancer Doesn’t Go Away talks more about this.

Follow-up care

Treatment for acute myeloid leukemia (AML) can continue for months or years. Even after treatment ends, you will need frequent follow-up exams – probably every few months for several years. It’s very important to go to all of your follow-up appointments. During these visits, your doctor will ask about any symptoms, examine you, and get blood tests or bone
marrow exams. Follow-up is needed to check for cancer recurrence, as well as possible side effects of certain treatments.

Almost any cancer treatment can have side effects. Some may last for only a short time, but others can last the rest of your life. Tell your cancer care team about any changes or problems you notice and about any concerns you have.

If the leukemia does come back, it is usually while the patient is still being treated or shortly after they have finished chemotherapy. If this happens, treatment would be as described in the section “What if the leukemia doesn’t respond or comes back after treatment?” It is unusual for AML to return if there are still no signs of the disease within a few years after treatment.

It is also very important to keep health insurance. Tests and doctor visits cost a lot, and even though no one wants to think of their cancer coming back, this could happen.

Should your cancer come back, our document *When Your Cancer Comes Back: Cancer Recurrence* can give you information on how to manage and cope with this phase of your treatment.

**Seeing a new doctor**

At some point after your treatment, you may be seeing a new doctor who doesn’t know anything about your medical history. It’s important to be able to give your new doctor the details of your diagnosis and treatment. Gathering these details soon after treatment may be easier than trying to get them at some point in the future. Make sure you have this information handy (and always keep copies for yourself):

- A copy of your pathology report(s) from any biopsies or surgeries
- If you had surgery, a copy of your operative report(s)
- If you stayed in the hospital, a copy of the discharge summary that the doctor wrote when you were sent home
- If you had radiation therapy, a copy of the treatment summary
- If you had chemotherapy or other medicines, a list of your drugs, drug doses, and when you took them
- The names and contact information of the doctors who treated your cancer

**Lifestyle changes after treatment for acute myeloid leukemia**

You can’t change the fact that you have had leukemia. What you can change is how you live the rest of your life – making choices to help you stay healthy and feel as well as you can.
This can be a time to look at your life in new ways. Maybe you are thinking about how to improve your health over the long term. Some people even start during treatment.

**Making healthier choices**

For many people, a diagnosis of leukemia helps them focus on their health in ways they may not have thought much about in the past. Are there things you could do that might make you healthier? Maybe you could try to eat better or get more exercise. Maybe you could cut down on alcohol, or give up tobacco. Even things like keeping your stress level under control may help. Now is a good time to think about making changes that can have positive effects for the rest of your life. You will feel better and you will also be healthier.

You can start by working on those things that worry you most. Get help with those that are harder for you. For instance, if you are thinking about quitting smoking and need help, call the American Cancer Society for information and support. Our tobacco cessation and coaching service can help increase your chances of quitting for good.

**Eating better**

Eating right can be hard for anyone, but it can get even tougher during and after cancer treatment. Treatment may change your sense of taste. Nausea can be a problem. You may not feel like eating and lose weight when you don’t want to. Or you may have gained weight that you can’t seem to lose. All of these things can be very frustrating.

If treatment causes weight changes or eating or taste problems, do the best you can and keep in mind that these problems usually get better over time. You may find it helps to eat small portions every 2 to 3 hours until you feel better. You may also want to ask your cancer team about seeing a dietitian, an expert in nutrition who can give you ideas on how to deal with these treatment side effects.

One of the best things you can do after cancer treatment is practice healthy eating habits. You may be surprised at the long-term benefits of some simple changes, like increasing the variety of healthy foods you eat. Getting to and staying at a healthy weight, eating a healthy diet, and limiting your alcohol intake can lower your risk for a number of types of cancer, as well as having many other health benefits.

To learn more, see *Nutrition for the Person With Cancer During Treatment: A Guide for Patients and Families*.

**Rest, fatigue, and exercise**

Extreme tiredness, called *fatigue*, is very common in people treated for cancer. This is not a normal tiredness, but a bone-weary exhaustion that often doesn’t get better with rest. For some people, fatigue lasts a long time after treatment, and can make it hard for them to be active and do the things they want to do. But exercise can help reduce fatigue. Studies have
shown that patients who follow an exercise program tailored to their personal needs feel better physically and emotionally and can cope better, too.

If you were sick and not very active during treatment, it’s normal for your fitness, endurance, and muscle strength to decline. Any plan for physical activity should fit your own situation. If you haven’t been active in a few years, you will have to start slowly – maybe just by taking short walks.

Talk with your health care team before starting anything. Get their opinion about your exercise plans. Then, try to find an exercise buddy so you’re not doing it alone. Having family or friends involved when starting a new activity program can give you that extra boost of support to keep you going when the push just isn’t there.

If you are very tired, you will need to learn to balance activity with rest. It’s OK to rest when you need to. Sometimes it’s really hard for people to allow themselves to rest when they are used to working all day or taking care of a household, but this is not the time to push yourself too hard. Listen to your body and rest when you need to. (For more information on dealing with fatigue, see *Fatigue in People With Cancer* and *Anemia in People With Cancer*. A list of some other documents about treatment side effects can be found in the “Additional resources for acute myeloid leukemia” section.)

Keep in mind exercise can improve your physical and emotional health.

- It improves your cardiovascular (heart and circulation) fitness.
- Along with a good diet, it will help you get to and stay at a healthy weight.
- It makes your muscles stronger.
- It reduces fatigue and helps you have more energy.
- It can help lower anxiety and depression.
- It can make you feel happier.
- It helps you feel better about yourself.

Getting regular physical activity also plays a role in helping to lower the risk of some cancers, as well as having other health benefits.

**Can I lower my risk of acute myeloid leukemia progressing or coming back?**

Most people want to know if they can make certain lifestyle changes to reduce their risk of cancer progressing or coming back. Unfortunately, for most cancers there isn’t much solid evidence to guide people. This doesn’t mean that nothing will help — it’s just that for the most part this is an area that hasn’t been well studied. Most studies have looked at lifestyle
changes as ways of preventing cancer in the first place, not slowing it down or preventing it from coming back.

At this time, not enough is known about AML to say for sure if there are things you can do that will help. Healthy behaviors such as not smoking, eating well, and staying at a healthy weight might help, but no one knows for sure. But we do know that these types of changes can have positive effects on your health that can extend beyond your risk of AML or other cancers.

So far, no dietary supplements have been shown to clearly help lower the risk of AML progressing or coming back. Again, this doesn’t mean that none will help, but it’s important to know that none have been proven to do so.

**How might treatment for acute myeloid leukemia affect your emotional health?**

During and after treatment, you may find yourself overcome with many different emotions. This happens to a lot of people.

You may find yourself thinking about death and dying. Or maybe you’re more aware of the effect the leukemia has on your family, friends, and career. You may take a new look at your relationships with those around you. Unexpected issues may also cause concern. For instance, you might be stressed by the costs of your treatment. You might also see your health care team less often over time and have more time on your hands. These changes can make some people anxious.

Almost everyone who is going through or has been through cancer can benefit from getting some type of support. You need people you can turn to for strength and comfort. Support can come in many forms: family, friends, cancer support groups, religious or spiritual groups, online support communities, or one-on-one counselors. What’s best for you depends on your situation and personality. Some people feel safe in peer-support groups or education groups. Others may feel more at ease talking one-on-one with a trusted friend or counselor. Whatever your source of strength or comfort, make sure you have a place to go with your concerns.

The cancer journey can feel very lonely. It’s not necessary or good for you to try to deal with everything on your own. And your friends and family may feel shut out if you don’t include them. Let them in, and let in anyone else you feel may help. If you aren’t sure who can help, call your American Cancer Society at 1-800-227-2345 and we can put you in touch with a group or resource that may work for you. You may also want to read our booklet *Distress in People with Cancer* or see the Emotional Side Effects section of our website for more information.
If treatment for acute myeloid leukemia stops working

If the leukemia keeps growing or comes back after one kind of treatment, it is possible that another treatment plan might still cure it, or at least keep it under control enough to help you live longer and feel better (see “What if acute myeloid leukemia doesn’t respond or comes back after treatment?”). Clinical trials also might offer chances to try newer treatments that could be helpful.

But when a person has tried many different treatments and the leukemia is no longer getting better, even newer treatments may no longer be helpful. If this happens, it’s important to weigh the possible limited benefits of a new treatment against the possible downsides, including treatment side effects. Everyone has their own way of looking at this.

This is likely to be the hardest part of your battle with leukemia – when you have been through many treatments and nothing’s working anymore. Your doctor might offer you new options, but at some point you may need to consider that treatment is not likely to improve your health or change your outcome or survival.

If you want to continue to get treatment for as long as you can, you need to think about the odds of treatment having any benefit and how this compares to the possible risks and side effects. In many cases, your doctor can estimate how likely it is the leukemia will respond to treatment you are considering. For instance, the doctor may say that more treatment might have about a 1 in 100 chance of working. Some people are still tempted to try this. But it is important to have realistic expectations if you do choose this plan.

Palliative care

No matter what you decide to do, it’s important that you feel as good as you can. Make sure you are asking for and getting treatment for any symptoms you might have, such as nausea or pain. This type of treatment is called palliative care.

Palliative care helps relieve symptoms, but it’s not expected to cure the disease. It can be given along with cancer treatment, or can even be cancer treatment. The difference is its purpose – the main goal of palliative care is to improve the quality of your life, or help you feel as good as you can for as long as you can. Sometimes this means using drugs to help with symptoms like pain or nausea.

For leukemia, palliative care often includes treatments such as blood transfusions that help relieve fatigue. Sometimes, though, the treatments used to control your symptoms are the same as those used to treat the leukemia. For instance, radiation might be used to help relieve bone pain. Or chemo might be used to help keep the number of leukemia cells in check. But this is not the same as treatment to try to cure the leukemia.
Hospice care

At some point, you may benefit from hospice care. This is special care that treats the person rather than the disease; it focuses on quality rather than length of life. Most of the time, it is given at home. Your leukemia may be causing problems that need to be managed, and hospice focuses on your comfort. You should know that while getting hospice care often means the end of treatments such as chemo and radiation, it doesn’t mean you can’t have treatment for the problems caused by the leukemia or other health conditions.

In hospice the focus of your care is on living life as fully as possible and feeling as well as you can at this difficult time. You can learn more about hospice in our document *Hospice Care*.

Staying hopeful is important, too. Your hope for a cure may not be as bright, but there is still hope for good times with family and friends – times that are filled with happiness and meaning. Pausing at this time in your treatment gives you a chance to refocus on the most important things in your life. Now is the time to do some things you’ve always wanted to do and to stop doing the things you no longer want to do. Though the leukemia may be beyond your control, there are still choices you can make.

To learn more

You can learn more about the changes that occur when treatment stops working, and about planning ahead for yourself and your family, in our documents *Advance Directives* and *Nearing the End of Life*.

What’s new in acute myeloid leukemia research and treatment?

Researchers are now studying the causes, diagnosis, supportive care, and treatment of acute myeloid leukemia (AML) at many medical centers, university hospitals, and other institutions.

Genetics of leukemia

Scientists are making great progress in understanding how changes in the DNA inside normal bone marrow cells can cause them to develop into leukemia cells. A greater understanding of the genes (regions of the DNA) involved in certain chromosomal translocations or other changes that often occur in AML is providing insight into why these cells become abnormal. As researchers have found more of these changes, it is becoming clear that there are many types of AML. Each of these might have different gene changes that affect how the leukemia will progress and which treatments might be most helpful. Doctors are now learning how to
use these changes to help them determine a person’s outlook and whether they should receive more or less intensive treatment.

In the future, this information may also be used to help develop newer targeted therapies against AML (see below).

**Detecting minimal residual disease**

Progress in understanding the DNA changes in AML cells has already provided highly sensitive tests for detecting the smallest amount of leukemia left after treatment (minimal residual disease), even when so few leukemia cells are present that they can’t be found by routine bone marrow tests.

For example, the polymerase chain reaction (PCR) test can identify even very small numbers of AML cells in a sample based on their gene translocations or rearrangements. A PCR test can be useful in determining how completely the treatment has destroyed the AML cells.

Doctors are now trying to determine what effect minimal residual disease has on a patient’s outlook, and how this might affect the need for further or more intensive treatment.

**Improving treatment**

Many studies are being done to find more effective and safer treatments for AML.

**Chemotherapy**

Researchers are looking to find the most effective combination of chemotherapy (chemo) drugs while still avoiding unwanted side effects. This is especially important in older patients, who are less likely to benefit from current treatments.

Researchers are studying many new chemo drugs for use in AML, including:

- Sapacitabine, a type of drug known as a *nucleoside analog*, which has shown promise as a treatment option for older patients with AML
- Laromustine, a type of chemo drug known as an *alkylating agent*, which is also being tested as an option for in older adults with AML
- Tipifarnib, a newer type of drug known as a *farnesyl transferase inhibitor*, which has also shown promise in early studies. This and similar drugs are now being tested in larger clinical trials.
- Bortezomib (Velcade®), a type of drug known as a *proteasome inhibitor*. It is helpful in treating multiple myeloma and certain types of lymphoma. A recent study looked at adding this drug to chemo for AML with promising results.
The effectiveness of chemo may be limited in some cases because the leukemia cells become resistant to it over time. Researchers are now looking at ways to prevent or reverse this resistance by using other drugs along with chemo. They are also looking at combining chemo with a number of newer types of drugs to see if this might work better.

**Treating acute promyelocytic leukemia (APL)**

Most patients with APL are first treated with ATRA combined with chemo. Recent research has shown that combining ATRA with arsenic trioxide is at least as good for many patients. This combination had been used before, but often only for patients who couldn’t get the standard chemo drugs. More patients may now get ATRA plus arsenic as their first treatment, allowing them to avoid some of the side effects of chemotherapy.

**Stem cell transplants**

Researchers continue to refine stem cell transplants to try to increase their effectiveness, reduce complications, and determine which patients are likely to be helped by this treatment. Many studies are under way to try to help determine exactly when autologous, allogeneic, and mini-transplants might best be used.

**Targeted therapies**

Chemo drugs can help many people with AML, but these drugs don’t always cure the disease. New targeted drugs that specifically attack some of the genetic changes seen in AML are now being developed. These drugs work differently than standard chemotherapy drugs.

In about 1 person out of 3 with AML, the leukemia cells have a mutation in the FLT3 gene. New drugs called FLT3 inhibitors, such as quizartinib, target this gene. They have shown activity against AML in early studies, especially when combined with chemotherapy. But so far, they are only available in clinical trials.

Changes in the c-KIT gene also appear to be important in some cases of AML. Drugs that target this gene, such as dasatinib (Sprycel®), are already used against other types of leukemia, and are now being studied against AML.

Many new drugs that target other changes in AML cells are now being studied as well. Examples include:

- Histone deacetylase (HDAC) inhibitors, such as vorinostat (Zolinza) and panobinostat
- Polo-like kinase (Plk) inhibitors, such as volasertib
- Aurora kinase inhibitors, such as AZD1152
Immunotherapy

The goal of immunotherapy is to boost the body’s immune system to help fight off or destroy cancer cells.

**Monoclonal antibodies:** These are man-made versions of immune system proteins (antibodies) that are designed to attach to specific targets, such as substances on the surface of cancer cells. Some work by boosting the body’s immune response against the cancer cells. Others have radioactive chemicals or cell poisons attached to them. When they are injected into the patient, these antibodies act like a homing device, bringing the radioactivity or poison directly to the cancer cells, which kills them. Monoclonal antibodies are often used to treat lymphomas, but their use in leukemias has been more limited.

Gemtuzumab ozogamicin (Mylotarg®) is a monoclonal antibody with a cell poison attached to it. At one time was approved to treat AML in older patients, but it was taken off the market when studies found it didn’t seem very helpful in the long term. However, in recent years it is again showing promise in certain patients in clinical trials.

**Immune checkpoint inhibitors:** An important part of the immune system is its ability to keep itself from attacking other normal cells in the body. To do this, it uses “checkpoints” – molecules on immune cells that need to be turned on (or off) to start an immune response. Cancer cells sometimes use these checkpoints to avoid being attacked by the immune system. But newer drugs that target these checkpoints hold a lot of promise as treatments. Some of these drugs are already being used to treat other types of cancer, and they are now being studied for use in AML as well.

**Vaccine therapy:** Scientists are studying ways to boost the immune reaction against leukemia cells by using vaccines. For example, in one vaccine, certain types of white blood cells (cells of the immune system) are removed from the patient’s blood and exposed to a protein found on many AML cells called Wilms’ tumor 1 protein (WT1). These cells are then given back to the patient by infusion into a vein (IV). In the body, these cells help other immune system cells to attack the leukemia. An early study of this vaccine showed promising results, but more research is needed to see if it will be useful. Other vaccines are being studied as well.

**CAR T-cell therapy:** This is a promising new way to get the immune system to fight leukemia. For this technique, immune cells called T cells are removed from the patient’s blood and altered in the lab so they have specific substances (called chimeric antigen receptors, or CARs) that will help them attach to leukemia cells. The T cells are then grown in the lab and infused back into the patient’s blood, where they can now seek out the leukemia cells and attack them.

This technique has shown very promising results in early clinical trials against some advanced, hard-to-treat types of lymphocytic leukemias. Although it’s not yet clear if it will work against AML, clinical trials are now in progress to find out. One concern with this treatment is that some people have had very serious side effects, including very high fevers...
and dangerously low blood pressure in the days after it’s given. Doctors are learning how to manage these side effects.

**Additional resources for acute myeloid leukemia**

More information from your American Cancer Society

Here is more information you might find helpful. You can read them online, or order free copies of our documents from our toll-free number, 1-800-227-2345.

**Dealing with diagnosis and treatment**

Health Professionals Associated With Cancer Care

Talking With Your Doctor (also in Spanish)

After Diagnosis: A Guide for Patients and Families (also in Spanish)

Nutrition for the Person With Cancer During Treatment: A Guide for Patients and Families (also in Spanish)

Coping With Cancer in Everyday Life (also in Spanish)

**Living with cancer**

Caring for the Patient With Cancer at Home: A Guide for Patients and Families (also in Spanish)

Distress in People With Cancer

Guide to Controlling Cancer Pain (also in Spanish)

Anxiety, Fear, and Depression

Living With Uncertainty: The Fear of Cancer Recurrence

When Your Cancer Comes Back: Cancer Recurrence

**Family and caregiver concerns**

Talking With Friends and Relatives About Your Cancer (also in Spanish)

Helping Children When a Family Member Has Cancer: Dealing With Diagnosis (also in Spanish)
What It Takes to Be a Caregiver

**Insurance and financial issues**

In Treatment: Financial Guidance for Cancer Survivors and Their Families (also in Spanish)
Health Insurance and Financial Assistance for the Cancer Patient (also in Spanish)

**More on cancer treatments**

A Guide to Cancer Surgery (also in Spanish)
A Guide to Chemotherapy (also in Spanish)
Understanding Radiation Therapy: A Guide for Patients and Families (also in Spanish)
Clinical Trials: What You Need to Know
Stem Cell Transplant (Peripheral Blood, Bone Marrow, and Cord Blood Transplants)

**Cancer treatment side effects**

Nausea and Vomiting
Anemia in People With Cancer
Fatigue in People With Cancer

**When treatment is no longer working**

When Cancer Doesn’t Go Away
Nearing the End of Life
Advance Directives
Hospice Care

Your American Cancer Society also has books that you might find helpful. Call us at 1-800-227-2345 or visit our bookstore online at cancer.org/bookstore to find out about costs or to place an order.

**National organizations and websites**

Along with the American Cancer Society, other sources of information and support include:
Acute myeloid leukemia

Leukemia & Lymphoma Society
Toll-free number: 1-800-955-4572
Website: www.lls.org

Has a variety of service programs and resources available throughout the US and Canada including: the Information Resource Center, staffed by health care professionals, available via the toll-free number; free publications on all forms of leukemia and related topics; First Connection, a phone-based peer support network for patients and survivors; family support groups; education teleconferences and webcasts – a schedule is on the website.

National Cancer Institute (NCI)
Toll-free number: 1-800-422-6237 (1-800-4-CANCER)
TTY: 1-800-332-8615
Website: www.cancer.gov

Offers a wide variety of free, accurate, up-to-date information about cancer to patients, their families, and the general public; also can help people find clinical trials in their area.

National Coalition for Cancer Survivorship (NCCS)
Toll-free number: 1-888-650-9127
Website: www.canceradvocacy.org

Has publications on many cancer-related topics; also offers the Cancer Survival Toolbox – a free program that teaches skills that can help people with cancer meet the challenges of their illness.

National Comprehensive Cancer Network (NCCN)
Website: www.nccn.org

Made up of experts from many of the nation’s leading cancer centers, the NCCN develops guidelines for doctors to use when treating patients. Also provides online information on other topics to help patients, caregivers, and families make informed decisions about cancer care.

Bone marrow and peripheral blood stem cell transplants

National Bone Marrow Transplant Link (nbmtLINK)
Toll-free number: 1-800-546-5268 (1-800-LINK-BMT)
Website: www.nbmtlink.org

Programs and services include: information and referrals to meet a wide range of needs; support via one-on-one conversations with trained peer support volunteers who are transplant survivors, caregivers, and donors; phone support groups, facilitated by
a clinical social worker, that link patients and families together to offer mutual support and coping strategies; and the nbmtLINK Online Resource Library – a comprehensive, searchable library giving access to the latest transplant information.

**Be the Match (formerly the National Marrow Donor Program)**

Toll-free number: 1-800-627-7692 (1-800-MARROW-2)

Website: www.bethematch.org

Provides a registry of volunteer bone marrow donors and cord blood units (the largest listing in the world), as well as a searchable listing of transplant centers that can be accessed directly at www.marrow.org/access. This listing contains information that may help a patient choose a transplant center. Also supports patients and their doctors throughout the transplant process, from diagnosis through survivorship; matches patients with the best donor or cord blood unit using innovative science and technology; has free educational materials; and offers financial assistance to eligible underinsured patients through the Patient Assistance Program.

*Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

**References**


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