Leukemia–Acute Myeloid (Myelogenous)

What is cancer?

The body is made up of trillions of living cells. Normal body cells grow, divide into new cells, and die in an orderly way. During the early years of a person's life, normal cells divide faster to allow the person to grow. After the person becomes an adult, most cells divide only to replace worn-out or dying cells or to repair injuries.

Cancer begins when cells in a part of the body start to grow out of control. There are many kinds of cancer, but they all start because of out-of-control growth of abnormal cells.

Cancer cell growth is different from normal cell growth. Instead of dying, cancer cells continue to grow and form new, abnormal cells. Cancer cells can also invade (grow into) other tissues, something that normal cells cannot do. Growing out of control and invading other tissues are what makes a cell a cancer cell.

Cells become cancer cells because of damage to DNA. DNA is in every cell and directs all its actions. In a normal cell, when DNA gets damaged the cell either repairs the damage or the cell dies. In cancer cells, the damaged DNA is not repaired, but the cell doesn't die like it should. Instead, this cell goes on making new cells that the body does not need. These new cells will all have the same damaged DNA as the first cell does.

People can inherit damaged DNA, but most DNA damage is caused by mistakes that happen while the normal cell is reproducing or by something in our environment. Sometimes the cause of the DNA damage is something obvious, like cigarette smoking. But often no clear cause is found.

In most cases the cancer cells form a tumor. Some cancers, like leukemia, rarely form tumors. Instead, these cancer cells involve the blood and blood-forming organs and circulate through other tissues where they grow.

Cancer cells often travel to other parts of the body, where they begin to grow and form new tumors that replace normal tissue. This process is called *metastasis*. It happens when the cancer cells get into the bloodstream or lymph vessels of our body.

No matter where a cancer may spread, it is always named for the place where it started. For example, breast cancer that has spread to the liver is still called breast cancer, not liver cancer. Likewise, prostate cancer that has spread to the bone is metastatic prostate cancer, not bone cancer.

Different types of cancer can behave very differently. For example, lung cancer and breast cancer are very different diseases. They grow at different rates and respond to different treatments. That is why people with cancer need treatment that is aimed at their particular kind of cancer.

Not all tumors are cancerous. Tumors that aren't cancer are called *benign*. Benign tumors can cause problems – they can grow very large and press on healthy organs and tissues. But they cannot grow into (invade) other tissues. Because they can't invade, they also can't spread to other parts of the body (metastasize). These tumors are almost never life threatening.

What is acute myeloid leukemia?

Acute myeloid leukemia (AML) has many names, including acute myelocytic leukemia, acute myelogenous leukemia, acute granulocytic leukemia, and acute non-lymphocytic leukemia. "Acute" means that the leukemia can progress quickly, and if not treated, would probably be fatal in a few months. "Myeloid" refers to the type of cell the leukemia starts from.

AML is a cancer that starts in cells that would normally develop into different types of blood cells. 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 called "How is acute myeloid leukemia classified?"

AML starts in the bone marrow (the soft inner part of the 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 leukemia.

Acute leukemia that develops in lymphocytes is called *acute lymphocytic leukemia* (ALL). For more information on this type of leukemia, see our document called *Leukemia: Acute Lymphocytic*.)

Normal bone marrow, blood, and lymphoid tissue

To understand the different types of leukemia, it helps to have some basic knowledge 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, pelvis, 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.

Blood stem cells go through a series of changes to make new blood cells. During this process, the cells develop into either lymphocytes (a kind of white blood cell) or other blood-forming cells. The other blood-forming cells can develop into 1 of the 3 main types of blood cell components:

- Red blood cells
- White blood cells (other than lymphocytes)
- Platelets

Red 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. Anemia (having too few red blood cells in the body) typically causes a person to feel tired, weak, and short of breath because the body tissues are not getting enough oxygen.

Platelets

Platelets are actually cell fragments made by a type of bone marrow cell called the *megakaryocyte*. Platelets are important in plugging up holes in blood vessels caused by cuts or bruises. A shortage of platelets is called *thrombocytopenia*. A person with thrombocytopenia may bleed and bruise easily.

White blood cells

White blood cells help the body fight infections. Lymphocytes are one type of white blood cell. The other types of white blood cells are granulocytes (neutrophils, basophils, and eosinophils) and monocytes. These other types are known as myeloid cells.

Lymphocytes: These 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 gland, the spleen, the

tonsils and adenoids, and is scattered throughout the digestive and respiratory systems and the bone marrow.

Lymphocytes develop from cells called *lymphoblasts* and become mature, infection-fighting cells. The 2 main types of lymphocytes are known as B lymphocytes (B cells) and T lymphocytes (T cells).

- B lymphocytes 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 white blood cells to recognize and destroy them.
- T lymphocytes can recognize cells infected by viruses and directly destroy these cells. They also help regulate the immune response.

Granulocytes: These are white blood cells that have granules in them that can be seen under the microscope as spots. 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. Granulocytes develop from blood-forming cells called *myeloblasts* to become mature, infection-fighting cells.

Monocytes: These white blood cells, which are related to granulocytes, also are important in protecting the body against bacteria. They start in the bone marrow as blood-forming *monoblasts* and develop into mature monocytes. 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 start making antibodies to fight them.

Any of the blood-forming or lymphoid cells from bone marrow can turn into a leukemia cell. Once this change takes place, the leukemia cells fail to go through their normal process of maturing. Leukemia cells may 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 functioning normally.

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 bone marrow cells cannot mature properly. Immature leukemia cells continue to reproduce and build up. 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 cells can mature partly but not completely. These cells may look fairly normal but they are not. They generally do not fight infection as well as do 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 for many years. But chronic leukemias are generally harder to cure than acute leukemias.

Myeloid leukemia versus lymphocytic leukemia

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

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

If the cancer starts in early forms of lymphocytes, it is called *lymphocytic* leukemia (also known as *lymphoid* or *lymphoblastic* leukemia). 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 contains information on acute myeloid leukemias of adults only. Chronic leukemias of adults and acute lymphocytic leukemia (ALL) of adults are discussed in other American Cancer Society documents. For information on AML in children, please see our document called Childhood Leukemia.

What are the key statistics about acute myeloid leukemia?

The American Cancer Society’s estimates for leukemia in the United States for 2014 are:

- About 52,380 new cases of leukemia (all kinds) and 24,090 deaths from leukemia (all kinds)
- About 18,860 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 66 years.

AML is slightly more common among men than among women. The lifetime risk of getting AML for the average man is about 1 in 227; for the average woman the risk is about 1 in 278.

Information on treatment success rates for adult AML 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. For example, exposing skin to strong sunlight is a risk factor for skin cancer. Smoking is a risk factor for a number of cancers.

But risk factors don't tell us everything. 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 not have had any known risk factors. Even if a person has a risk factor and develops cancer, it is often very hard to know how much that risk factor may have contributed to the cancer.

There are a few 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 may be increased by exposure to certain chemicals. 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 present in cigarette smoke, and some glues, cleaning products, detergents, art supplies, and paint strippers.

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

Cancer treatment

Patients who are treated with certain cancer 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 poisons 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 poisons include the drugs etoposide and teniposide, mitoxantrone, and the anthracyclines (epirubicin, doxorubicin).

For more information, see our document *Second Cancers After Cancer Treatment*.

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, usually within 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 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 a person’s exposure to radiation as much as possible.

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

Certain blood disorders

Patients 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 developing AML is increased further if treatment for these disorders includes some types of chemotherapy or radiation.

Some patients 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
- Blackfan-Diamond syndrome
- Schwachman syndrome
- Li-Fraumeni syndrome
- Neurofibromatosis I
- Severe congenital neutropenia (also called Kostmann syndrome)

Chromosome problems present at birth are also linked to a higher risk of AML, these include:

- 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 strong risk of also getting AML.

Gender

AML is more common in males than in females, but the reasons for this are 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 called “What are the risk factors for acute myeloid leukemia?”), but most do not. The cause of their cancer remains unknown at this time. Even when a person has one or more risk factors, there is no way to tell whether it actually caused the cancer.

During the past few years, scientists have made great progress in understanding 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 molecules of DNA in each cell. DNA is the chemical that makes up our genes – the instructions for how our cells function. We look like our parents because they are the source of our DNA. But our genes affect more than the way we look.

Some genes contain instructions for controlling when our cells grow and divide. Certain abnormal genes that promote cell division 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 may 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 commonly found in AML cells.

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 normally present 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 that would normally help a cell to mature.

- *Deletions* occur when part of a chromosome is lost. This may 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 is 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.

Doctors are trying to figure out why these changes occur and how each of them might lead to leukemia. Different cases of AML can have different chromosome changes. Some are more common in leukemia that occurs after chemotherapy for another cancer. Some changes are more common than others, and some 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 called "How is acute myeloid leukemia classified?"

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

Most DNA mutations related to AML occur during a person's lifetime, rather than having been inherited before birth. They may result from exposure to radiation or cancer-causing chemicals, but in most cases the reason they occur is not known.

Can acute myeloid leukemia be prevented?

It's not known what causes most cases of acute myeloid leukemia (AML). Since most leukemia patients have no known risk factors, at the present time there is no way to prevent it from developing.

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 (see the section called “What are the risk factors for acute myeloid leukemia?”). Doctors are trying to figure out how to treat these cancers without raising the risk of developing secondary leukemia. But for now, the obvious benefits of treating life-threatening cancers with chemotherapy and radiation therapy 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 accounts for only a small portion of leukemia cases.

Can acute myeloid leukemia be found early?

For many types of cancers, diagnosis at the earliest possible stage makes treatment much more effective. 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 (see the section called “How is acute myeloid leukemia diagnosed?”) to the doctor right away.

Some people are known to be at increased risk of AML because of 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 receive careful, regular medical checkups. They do not usually develop leukemia, but they and their doctors should be familiar with possible symptoms of AML.

Signs and symptoms of acute myeloid leukemia

Acute myeloid leukemia (AML) can cause many different signs and symptoms. Some occur more commonly with certain subtypes.

Generalized symptoms

Patients with AML often have several non-specific (generalized) symptoms. These can include weight loss, fatigue, fever, night sweats, and 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

Most 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.

Low red blood cell counts (*anemia*) can cause:

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

Infections can occur because of a shortage of normal white blood cells (a condition 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 do not protect them against infection the way normal white blood cells do..

A shortage of blood platelets (*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 (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 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 lung 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 present with only a chloroma and 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 may spread to other organs. Spread to central nervous system (brain and spinal cord) can cause headaches, weakness, seizures, vomiting, trouble with balance, facial numbness, or blurred vision. On rare occasions AML may spread to the eyes, testicles, kidneys, or other organs.

Enlarged lymph nodes

In rare cases, AML may spread to lymph nodes. Affected nodes in the neck, groin, underarm areas, or above the collarbone may be felt as lumps under the skin.

Although any of these 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 your doctor right away 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 may have acute myeloid leukemia (AML), but tests are needed to confirm the diagnosis.

Medical history and physical exam

If signs or symptoms suggest the possibility of leukemia, the doctor will want to obtain a thorough medical history, including how long your symptoms have been present and whether or not there is any history of exposure to risk factors.

During the physical exam, the doctor will likely pay close attention to the eyes, mouth, skin, lymph nodes, liver and spleen, and the 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.), your doctor will test your blood counts. If the results suggest leukemia may be the cause, the doctor may refer you to a cancer doctor, who may run one or more of the tests described below.

Types of samples used to test for acute myeloid leukemia

If signs and symptoms and/or the results of the physical exam suggest you may have leukemia, the doctor will need to check samples of cells from the blood and bone marrow to be sure of the diagnosis. 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 with 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 (about 1 teaspoon). 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 (about 1/16 inch in diameter and 1/2 inch long) is removed with a slightly larger needle that is twisted as it is pushed down into the bone. This causes a feeling of pressure, and rarely 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. They may also be 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. Leukemia can 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 a sample of this fluid is called a *lumbar puncture* (*spinal tap*).

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 directed between the bones of the spine into the area around the spinal cord to withdraw some of the fluid.

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 central nervous system (CNS).

A lumbar puncture is sometimes used to deliver chemotherapy drugs into the CSF to 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 different cells in the blood, such as the red blood cells, the white blood cells, and the 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. These tests look at how the different types of cells in the blood appear under the microscope and how many of them there are. Changes in the numbers and the appearance of these 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 bloodstream. These immature cells do not function 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 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 the clotting ability of the blood.

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 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 similar to normal immature cells in the bone marrow. But in normal bone marrow, the blast count is 5% or less. For a patient to be considered to be in remission after treatment, the blast percentage in the bone marrow must be no higher than 5%.

Sometimes just counting and looking at the cells does not 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 these substances are present on their surfaces. 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. Specific types of leukemia cells have different antigens depending on their cell of origin 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 changes in chromosomes are also possible (see below). Recognizing these changes can help identify certain types of AML and may be important in determining the outlook for the patient.

This test result usually takes about 2 to 3 weeks because the leukemia cells must grow in lab dishes for a couple of weeks before their chromosomes are ready to be looked at under the microscope.

The results of cytogenetic testing are written in a shorthand form that describes which chromosome changes are present.

- 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 upside down and is now in reverse order but is still attached to the chromosome it originated from.
- 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 DNA 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 present 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 does not usually form visible 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 tell 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 is a type of x-ray that produces 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).

A CT scanner has been described as a large donut, with a narrow table in the middle opening. You will 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.

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 ever had a reaction to any contrast material used for x-rays.

In some cases, a CT can be used to guide a biopsy needle precisely into a suspected abnormality, such as an abscess. For this procedure, called a *CT-guided needle biopsy*, you remain on the CT scanning table while a radiologist moves a biopsy needle through the skin and toward the location of the mass. CT scans are repeated until the needle is within the mass. A sample is then removed 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. The PET/CT scan allows the doctor to 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 provide detailed images of soft tissues in the body. But MRI scans use radio waves and strong magnets instead of x-rays. The energy from the radio waves is absorbed by the body and then released in a pattern formed by the type of body tissue and by certain diseases. A computer translates the pattern into a very detailed image of parts of the body. A contrast material called gadolinium is often injected into a vein before the scan to better see details. This is a different contrast from that used for CT scans, so being allergic to one doesn't mean you are allergic to the other.

MRI scans are very helpful in looking at the brain and spinal cord, but they are not often 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 produce a picture of internal organs or masses. Most often for this test, a small, microphone-like instrument called a transducer is placed on the skin over the area to be examined (the skin is first lubricated with gel). It emits sound waves and picks up the echoes as they bounce off the organs. The echoes are converted by a computer into an image that is displayed on a computer screen.

Ultrasound can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside your abdomen such as the kidneys, liver, and spleen.

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?

Most types of cancers are assigned numbered stages to describe their extent in the body, based on the size of the tumor and how far the cancer has spread.

Acute myeloid leukemia (AML), on the other hand, does not usually form tumor masses. It generally involves all of the bone marrow in the body and, in some cases, may have spread to other organs, such as the liver and spleen. Therefore the outlook for the patient with AML depends on other information, such as the subtype of AML (determined by lab tests), the age of the patient, and other lab test results.

Two systems have been used to classify AML into subtypes – 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 acute myeloid leukemias into subtypes, M0 through M7, based on the type of cell from which the leukemia developed and how mature the cells are. This was based largely on how the leukemia cells looked under the microscope after routine staining.

FAB subtype	**Name**
M0	Undifferentiated acute myeloblastic leukemia
M1	Acute myeloblastic leukemia with minimal maturation
M2	Acute myeloblastic leukemia with maturation
M3	Acute promyelocytic leukemia (APL)
M4	Acute myelomonocytic leukemia
M4 eos	Acute myelomonocytic leukemia with eosinophilia
M5	Acute monocytic leukemia
M6	Acute erythroid leukemia
M7	Acute megakaryoblastic leukemia

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

Some subtypes of AML defined in the FAB system are linked with certain symptoms. For example, bleeding or blood clotting problems are often a problem for patients with the M3 subtype of AML, also known as acute promyelocytic leukemia (APL).

Identifying APL is very important for 2 reasons. First, certain complications of APL can often be prevented by appropriate treatment. Second, APL is treated differently from most other forms of AML – it responds to drugs like retinoids (drugs related to vitamin A).

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 known to impact prognosis (outlook). In 2001, the World Health Organization (WHO) published a newer system that includes some of these factors to try to help better classify cases of AML based on a patient's outlook.

The WHO classification system divides AML into several broad 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 changes in chromosome 11
- APL (M3), which usually has translocation between chromosomes 15 and 17

AML with multilineage dysplasia (more than one abnormal myeloid cell type is involved)

AML related to previous chemotherapy or radiation

AML not otherwise specified (includes cases of AML that don't fall into one of the above groups; similar to the FAB classification)

- Undifferentiated AML (M0)
- AML with minimal 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)

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

Prognostic factors for acute myeloid leukemia

Leukemia treatment has improved over the years, so research has focused on why some patients have a better chance to be cured than others. Differences among patients that affect response to treatment are called *prognostic factors.* Prognostic factors help doctors decide if people with a certain type of leukemia should receive more or less treatment. Some of these include:

Chromosome abnormalities

Chromosome changes give one clue to prognosis. Not all patients have these abnormalities. Those listed below are the most common, but there are many others. 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

Newer tests allow doctors to find changes within specific genes on chromosomes. People who 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 the leukemias.

Markers on the leukemia cells

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

Age

Older patients (over 60) generally do not fare as well as younger patients. Some of this may be because they are more likely to have unfavorable chromosome abnormalities. Older patients may 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 disorders or cancers

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 regular chemotherapy drugs don't penetrate that area.

Status of acute myeloid leukemia after treatment

Not surprisingly, how well a leukemia responds to treatment also has an effect on long-term prognosis.

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 leukemia cells remain 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 be relapsed, they must have more than 5% blast cells present in the 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

This section starts with general comments about types of treatments used for acute myeloid leukemia (AML). This is followed by a discussion of the typical treatment approach for AML. The treatment of acute promyelocytic leukemia (APL) is different from other subtypes, and is discussed separately.

As noted earlier, adult AML is not a single disease. It is really a group of related diseases, and patients with different subtypes of AML vary in their outlook and response to treatment. Treatment options for each patient are based on the subtype and lab tests of the leukemia cells, as well as certain other prognostic features (described in the section called “How is acute myeloid leukemia classified?”).

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. Surgery and radiation therapy may be used in special circumstances. See the “Additional resources for acute myeloid leukemia” section for other, more detailed materials on the different types of cancer treatments and their side effects.

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 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.

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 acute myeloid leukemia (AML) is usually divided into 2 phases:

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

For some types of AML, there is a 3rd phase: maintenance.

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).

Maintenance involves giving a low dose of a chemo drug for months or years after consolidation is finished. This is often used for AML M3, but 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 work by attacking 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, 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 may include:

- Hair loss
- Mouth sores
- Loss of appetite
- Nausea and vomiting

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

- Increased risk of infections (due to low white blood cell counts)
- Easy bruising or bleeding (due to low blood platelets)
- Fatigue (due to low 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 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 is 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 when they come in contact with you.
- Avoid large crowds and people who are sick.

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

Many of the 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, cytarabine can cause certain problems, especially when used at high doses. These can include dryness in the eyes and effects on certain parts of the brain, which can lead to coordination and balance problems. The drug dose may need to be reduced or stopped altogether if these side effects

appear. Anthracyclines can cause heart damage so they may not be able to be used in someone who already has heart problems.

Other organs that could be directly damaged by chemo drugs include the kidneys, liver, testicles, ovaries, heart, and lungs. Doctors and nurses carefully monitor treatment to reduce 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 involving organs can be permanent.

Tumor lysis syndrome is another possible side effect of chemo. This syndrome can be seen in patients who have large numbers of leukemia cells in the body before treatment, and so 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 may 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.

Our document, *Understanding Chemotherapy: A Guide for Patients and Families* has more information about chemo and its side effects.

Other drugs for acute myeloid leukemia

Acute promyelocytic leukemia (APL or AML M3) is different from other types of acute myeloid leukemia (AML) in some important ways. First, the leukemia cells (or blasts) contain proteins that when released into the bloodstream 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.

This was a big problem in the past, since treating APL with regular chemotherapy (chemo) drugs made those cells die and release these proteins into the bloodstream. Patients sometimes died from complications from the out of control clotting. Then 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 so these drugs are called *differentiation agents*. Since the blasts don't die, they don't release the harmful proteins into the blood, and the clotting process doesn't get 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 treatment of APL. It is often given along with chemo − an anthracycline drug with or without cytarabine. 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 keep the leukemia from coming back. For that part of the treatment, it may be used with chemo, with arsenic trioxide, or with both chemo and arsenic trioxide.

ATRA can have side effects similar to those seen if you take too much vitamin A. Symptoms 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 those of 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. But doctors found that it can act in a way similar to ATRA in patients with APL. It can be given with ATRA, but it is also helpful in treating patients with APL whose leukemia came back after treatment with ATRA plus chemo. In those patients, ATO is given without chemo.

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

Differentiation syndrome

The most important side effect of either of these drugs is a syndrome known as *differentiation syndrome*. It is most often only seen during the first cycle of treatment. Symptoms include 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. This used to be called *retinoic acid syndrom*e, until doctors realized that it happened after treatment with arsenic and not just ATRA.

Surgery for acute myeloid leukemia

Surgery has a very limited role in the treatment of acute myeloid leukemia. Because leukemia cells spread widely throughout the bone marrow and to many other organs, it is not possible to cure this type of cancer with surgery. Surgery rarely has any role even in the diagnosis, since a bone marrow aspirate and biopsy can usually diagnose leukemia. 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 small plastic tube, called a *central venous catheter* or *venous access device* (VAD), is inserted into a large vein. This may be done by a surgeon in the operating room, or by a special type of radiologist. The end of the tube is 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. This lowers the number of needle sticks needed during treatment. It is very important for the patient to learn how to care for the VAD to keep it from getting infected.

Radiation therapy for acute myeloid leukemia

Radiation therapy uses high-energy radiation to kill cancer cells. Radiation therapy is usually not part of the main treatment for people with acute myeloid leukemia (AML), but it is used in certain situations.

There are a few instances in which radiation therapy may be used to help treat leukemia:

- 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 bone marrow or peripheral blood 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 may work more quickly.
- Radiation can also be used to reduce pain in an area of bone that is invaded by leukemia, if chemotherapy hasn’t helped.

External beam radiation therapy, in which a machine delivers a beam of radiation to a specific part of the body, is the type of radiation used most often for AML. 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. Radiation therapy is much like getting an x-ray, but the radiation is more intense. The procedure itself is painless. 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) and an increased risk of infection (from low white blood cell counts).

More information on radiation therapy can be found in the radiation section of our website, or in our document *Understanding Radiation Therapy: A Guide for Patients and Families.*

Stem cell transplant for acute myeloid leukemia

The usual doses of chemotherapy drugs can cause serious side effects to quickly dividing tissues such as the bone marrow. Even though higher doses of these drugs might be more effective, they are not 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.

A stem cell transplant (SCT) allows doctors to use higher doses of chemotherapy (sometimes combined with radiation therapy). After that treatment is finished, the patient receives an infusion of blood-forming stem cells to restore the bone marrow.

Blood-forming stem cells used for a transplant are obtained either from the blood (for a peripheral blood stem cell transplant, or PBSCT) or from the bone marrow (for a bone marrow transplant, or BMT). Sometimes stem cells harvested from a baby's umbilical cord are used.

Types of transplants

There are 2 main types of stem cell transplants: allogeneic and autologous. They differ with regard to the source of the blood-forming stem cells.

Allogeneic stem cell transplant

This is the most common form of SCT used to treat acute leukemia. In an allogeneic transplant, the stem cells come from someone else – usually a donor whose tissue type is almost identical to 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 ideal donor is a close relative, such as a brother or sister, if they are a match. If no close relatives match, a matched unrelated donor (MUD) may be an option in some cases, but use of stem cells from a MUD is linked to more complications. The stem cells from an unrelated donor come from volunteers whose tissue type has been stored in a central registry and matched with that of the patient. 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.

Using donor cells for SCT for acute myeloid leukemia (AML) is preferred because leukemia is a disease of the blood and bone marrow, so giving the patient his or her own cells back may mean giving leukemia cells. 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 will attack them. This effect doesn't happen with autologous stem cell transplants

An allogeneic transplant is often the preferred type of transplant for AML when it is available, but its use is limited by the need for a matched donor. It is also limited by its side effects, which are too severe for most older people.

Non-myeloablative transplant (mini-transplant): Many older people can't tolerate a standard allogeneic transplant that uses high doses of chemotherapy. Some may be able to have a non-myeloablative transplant (also known as a *mini-transplant* or *reduced-intensity transplant*), where they receive lower doses of chemotherapy and radiation that do not completely destroy the cells in their bone marrow. They then receive 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).

Doctors have learned that if they use small doses of certain chemotherapy drugs and low doses of total body radiation, an allogeneic transplant can still sometimes work with much less toxicity. In fact, a patient can receive a non-myeloablative transplant as an outpatient. The major complication is graft-versus-host disease.

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 peripheral 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 section called "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, but the high-dose chemotherapy can still cause major side effects. The patient is getting his or her own cells back, so the risk of some complications is smaller. 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 is 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 peripheral blood are collected, frozen, and stored. The patient receives high-dose chemotherapy 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.)

The 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 platelet production and, several weeks later, new red blood cell production.

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 the discharge date, 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

Bone marrow or peripheral blood SCT is a complex treatment. If the doctors think a patient 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 bone marrow transplant programs may not have experience in certain types of transplants, especially transplants from unrelated donors.

SCT is very expensive (more than $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.

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” for details), although they may be more severe. These side effects are due to damage to the bone marrow and other quickly dividing tissues of the body. 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 for infection from bacteria, viruses, or fungi. 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.

Some complications and side effects can persist for a long time or may not occur until months or years after the transplant. These include:

- Graft-versus-host disease (GVHD), which can occur in allogeneic (donor) transplants. This happens when the donor immune system cells attack tissues of the patient’s skin, liver, and digestive tract. Symptoms can include weakness, fatigue, dry mouth, rashes, nausea, diarrhea, yellowing of the skin and eyes (jaundice), and muscle aches. In severe cases, GVHD can be life-threatening. GVHD is often described as either acute or chronic, based on how soon after the transplant it begins. Drugs that weaken the immune system are often given to try to keep GVHD under control.
- Damage to the lungs, causing shortness of breath
- Damage to the ovaries in women, causing infertility and loss of menstrual periods
- Damage to the thyroid gland that causes 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 will need to have part of the bone and the joint replaced.

Graft-versus-host disease is the most serious complication of allogeneic (donor) stem cell transplants. The most common symptoms are severe skin rashes and severe diarrhea. The liver and lungs may also be damaged. The patient may also become tired easily and have muscle aches. Sometimes the graft-versus-host disease becomes chronic and disabling and, if it is severe enough, can be life-threatening. Drugs that affect the immune system may be given to try to control it.

On the positive side, graft-versus-host disease also leads to “graft-versus-leukemia” activity. Any leukemia cells remaining after chemotherapy and radiation therapy may be killed by the immune reaction of the donor cells.

For more information on stem cell transplants, see our document called *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 cancer. 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 your type of cancer. 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 get a closer look at promising new treatments or procedures.

If you would like to take part in a clinical trial, you should 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 clinical trials that meet your medical needs. You can reach this service at 1-800-303-5691 or on our Web site at www.cancer.org/clinicaltrials. You can also get a list of current clinical trials by calling the National Cancer Institute's Cancer Information Service toll-free at 1-800-4-CANCER (1-800-422-6237) or by visiting the NCI clinical trials Web site at www.cancer.gov/clinicaltrials.

There are requirements you must meet to take part in any clinical trial. If you do qualify for a clinical trial, it is up to you whether or not to enter (enroll in) it.

Clinical trials are one way to get state-of-the art cancer treatment. In some cases they may be the only way to get access to newer treatments. They are also the only way for doctors to learn better methods to treat cancer. Still, they are not right for everyone.

You can get a lot more information on clinical trials in our document called *Clinical Trials: What You Need to Know*. You can read it on our website or call us to have it sent to you.

Complementary and alternative therapies for acute myeloid leukemia

When you have cancer you are likely to hear about ways to treat your cancer or relieve symptoms that your doctor hasn't mentioned. Everyone from friends and family to Internet groups and websites may 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. Delays or interruptions in your medical treatments may give the cancer more time to grow and make it less likely that treatment will help.

Finding out more

It is 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 of these alternative methods have not been tested and proven to work in treating cancer.

As you consider your options, here are 3 important steps you can take:

- Look for “red flags” that 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?
- Talk to your doctor or nurse about any method you are thinking about using.
- Contact us at 1-800-227-2345 to learn more about complementary and alternative methods in general and to find out about the specific methods you are looking at. You can also check them out on the *Complementary and Alternative Medicine* page of our website.

The choice is yours

Decisions about how to treat or manage your cancer 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)

Treating leukostasis

In some cases, people with AML may 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, "How is acute myeloid leukemia diagnosed?" Chemo may take a few days to lower the number of cells in the blood. In the meantime, *leukapheresis* (sometimes just called *pheresis*) may 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 cells and plasma to the patient. Two IV lines are required – the blood is removed through one IV, and then is returned to the patient through the other IV. Sometimes, a single large catheter is placed in the neck or under the collar bone for the pheresis – instead of using IV lines in the 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 all visible leukemia. How intense the treatment is may 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 may 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, and so 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 be given into the cerebrospinal fluid (CSF) as well.

Induction destroys most of the normal bone marrow cells as well as the leukemia cells. Most patients develop dangerously low blood counts, and the patient 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 down for 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 few blasts (less than 10%). 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 that time. When the blood cell counts recover, the doctor will check cells in a bone marrow sample to see if the leukemia is in remission. If the biopsy done a week or 2 after the chemo treatment 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 looking at the first bone marrow whether the leukemia is still there, another bone marrow biopsy may be done again in about a week.

Remission induction usually does not destroy all the leukemia cells, and a small number often persist. 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 AML consolidation therapy are:

- Several cycles of high-dose cytarabine (ara-C) chemo (this is 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 a stem cell transplant. Patients first receive very high doses of chemo to destroy all bone marrow cells. This is followed by either an allogeneic (from a donor) or autologous (patient's own) stem cell transplant to restore blood cell production. 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 or daunorubicin
- Non-myeloablative stem cell transplant (mini-transplant)

It is not always clear which of the treatment options is best for consolidation. Each has pros and cons. Doctors look at several different factors when recommending what type of post-remission therapy a patient should receive. 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 receive a more intensive program, which might involve 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 age of the patient.** 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. 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 (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. 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, but may be given every so often as long as it seems helpful.

Sometimes, these patients may be treated with drugs used to treat myelodysplastic syndrome, like 5-azacytidine (Vidaza) or decitabine (Dacogen). These drugs are not approved to treat AML, but still may be 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 may develop serious blood-clotting or bleeding problems. This used to be treated with blood-thinning medicines, but is less often a problem now that treatment includes drugs like all-trans-retinoic acid (ATRA). Other treatments might include 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-chemotherapy drug, all-trans-retinoic acid (ATRA), which is a relative of vitamin A. ATRA 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 drug called arsenic trioxide (Trisenox). This is often used in patients who can't tolerate an anthracycline drug, but is 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.

Side effects

The possible side effects from the chemotherapy part of this treatment are generally the same as those of standard AML induction chemotherapy. But both ATRA and arsenic can cause a problem called *differentiation syndrome* (it used to be called *retinoic acid syndrome)*. Symptoms of this syndrome include:

- Breathing problems due to fluid buildup in the lungs
- Low blood pressure
- Kidney damage
- Severe fluid buildup elsewhere in the body

It can often be treated by stopping the drug for a while and giving a steroid such as dexamethasone.

Treatment response rates for acute myeloid leukemia

For most types of acute myeloid leukemia

Induction is successful in about 65% of all acute myeloid leukemia (AML) patients who get standard induction chemotherapy (chemo) with daunorubicin and cytarabine. 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 have more chemo (consolidation). A common regimen is 3 or 4 cycles of high dose ara-C (HiDAC). 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 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 also has a higher risk of death as a complication.

Older patients generally don't do as well as those younger than 60. They have trouble tolerating intensive treatment and often have chromosome changes in their leukemia cells that are linked to a poorer outlook.

For acute promyelocytic leukemia (APL)

More than 90% of patients 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 the 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 may 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 6 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 6 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 attempting to cure the leukemia. This may be 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 is important that you be as comfortable as possible. Treatments that may be helpful include radiation 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.

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.

More treatment information about acute myeloid leukemia

For more details on treatment options – including some that may not be addressed in this document – the National Comprehensive Cancer Network (NCCN) and the National Cancer Institute (NCI) are good sources of information.

The NCCN, made up of experts from many of the nation's leading cancer centers, develops cancer treatment guidelines for doctors to use when treating patients. Those are available on the NCCN Web site (www.nccn.org).

The NCI provides treatment guidelines via its telephone information center (1-800-4-CANCER) and its Web site (www.cancer.gov). Detailed guidelines intended for use by cancer care professionals are also available on www.cancer.gov.

What should you ask your doctor about acute myeloid leukemia?

It is important to have frank, open, and honest communications with your doctor about your condition. Your doctor and the rest of the cancer care team want to answer all of your questions. 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?
- Will I need other tests before we can decide on treatment?
- 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 are the risks and side effects to the treatments that you recommend?
- What should I do to be ready for treatment?
- How long will treatment last? What will it be like? Where will it be done?
- 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 so that you can plan your work schedule. 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.

What happens after treatment for acute myeloid leukemia?

Completing treatment can be both stressful and exciting. You may be relieved to finish treatment, but find it hard not to worry about cancer coming back. (When cancer 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 cancer survivors have learned to live with this uncertainty and are leading full lives. Our document called *Living With Uncertainty: The Fear of Cancer Recurrence*, gives more detailed information on this. You can read it online, or call us to have a free copy sent to you.

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 is very important to go to all of your follow-up appointments. During these visits, your doctor will ask about any symptoms, do physical exams, and order 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 a few weeks to months, but others can last the rest of your life. This is the time for you to talk to your cancer care team about any changes or problems you notice and any questions or concerns you have.

If the leukemia comes back, it is usually while the patient is being treated or shortly after they have finished chemotherapy. If this happens, treatment would be as described in the section called "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 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 called *When Your Cancer Comes Back: Cancer Recurrence* can give you information on how to manage and cope with this phase of your treatment. You can get a copy by calling 1-800-227-2345.

Seeing a new doctor

At some point after your cancer diagnosis and treatment, you may find yourself seeing a new doctor who does not know anything about your medical history. It is important that you 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:

- 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 were in the hospital, a copy of the discharge summary that doctors prepare when patients are 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 doctor may want copies of this information for his records, but always keep copies for yourself.

Lifestyle changes after treatment for acute myeloid leukemia

You can’t change the fact that you have had cancer. 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 cancer treatment.

Making healthier choices

For many people, a diagnosis of cancer 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 the 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. This 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 caused 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 put healthy eating habits into place. 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 may lower your risk for a number of types of cancer, as well as having many other health benefits.

For more information about nutrition, see our document Nutrition for the Person With Cancer During Treatment: A Guide for Patients and Families. The section called "Additional resources for acute myeloid leukemia" has a list of some other documents that you may find helpful.

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 doesn't get better with rest. For some people, fatigue lasts a long time after treatment, and can make it hard for them to exercise and do other 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 is normal for your fitness, endurance, and muscle strength to decline. Any plan for physical activity should fit your own situation. An older person who has never exercised will not be able to take on the same amount of exercise as a 20-year-old who plays tennis twice a week. If you haven't exercised 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 exercise 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 balance activity with rest. It is 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, please 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.

And long term, we know that getting regular physical activity plays a role in helping to lower the risk of some cancers, as well as having other health benefits.

How does treatment for acute myeloid leukemia affect your emotional health?

When treatment ends, you may find yourself overcome with many different emotions. This happens to a lot of people. You may have been going through so much during treatment that you could only focus on getting through each day. Now it may feel like a lot of other issues are catching up with you.

You may find yourself thinking about death and dying. Or maybe you're more aware of the effect the cancer has on your family, friends, and career. You may take a new look at your relationship with those around you. Unexpected issues may also cause concern. For instance, as you feel better and have fewer doctor visits, you will see your health care team less often and have more time on your hands. These changes can make some people anxious.

Almost everyone who 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, church 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 would rather talk in an informal setting, such as church. 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 is 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 do not 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.

If treatment for acute myeloid leukemia stops working

If cancer keeps growing or comes back after one kind of treatment, it is possible that another treatment plan might still cure the cancer, or at least shrink it enough to help you live longer and feel better. But when a person has tried many different treatments and the cancer has not gotten any better, the cancer tends to become resistant to all treatment. If this happens, it's important to weigh the possible limited benefits of a new treatment against the possible downsides. Everyone has their own way of looking at this.

This is likely to be the hardest part of your battle with cancer – when you have been through many medical treatments and nothing's working anymore. Your doctor may 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 cancer will respond to treatment you are considering. For instance, the doctor may say that more chemo or radiation might have about a 1% chance of working. Some people are still tempted to try this. But it is important to think about and understand your reasons for choosing this plan.

No matter what you decide to do, you need to 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 is 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 purpose 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 cancer. For instance, radiation might be used to help relieve bone pain caused by cancer that has spread to the bones. Or chemo might be used to help shrink a tumor and keep it from blocking the bowels. But this is not the same as treatment to try to cure the cancer.

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 cancer 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 cancer 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 documents *Hospice Care* and *Nearing the End of Life*. They can be read online, or call us to have free copies mailed to you.

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 cancer 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 cancer may be beyond your control, there are still choices you can make.

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 a person's DNA can cause normal bone marrow cells to develop into leukemia cells. A greater understanding of the genes (regions of the DNA) involved in certain translocations or other chromosomal changes that often occur in AML is providing insight into why these cells become abnormal. 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).

Gene expression profiling

This new lab technique is being studied to help identify and classify different cancers. Instead of looking at single genes, this test is able to look at the patterns of many different genes in the cancer cells at the same time. This may add to the information that comes from the currently used lab tests.

Detecting minimal residual disease

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

The polymerase chain reaction (PCR) test can identify AML cells based on their gene translocations or rearrangements. This test can find one leukemia cell among a million normal cells. 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

Studies are being done 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.

Sapacitabine, which is a type of drug known as a nucleoside analog, has shown promise as a treatment option for older patients with AML.

Laromustine, a type of chemo drug known as an alkylating agent, 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, has also shown promise in early studies. Farnesyl transferase inhibitors are drugs that keep a protein that is very active in cancer from functioning. These drugs are now being tested in larger clinical trials.

Bortezomib (Velcade®) is a type of drug known as a proteasome inhibitor. It is helpful in the treatment of 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. Researchers are now looking at ways to prevent or reverse this resistance by using other drugs along with chemo.

Treating acute promyelocytic leukemia

Most patients with acute promyelocytic leukemia are treated with ATRA combined with chemo. A recent study has shown that combining ATRA with arsenic trioxide was 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. With the results of this study, ATRA plus arsenic may be used more often.

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

New targeted drugs that specifically attack some of the genetic changes seen in AML are now being developed.

About 1 person out of 3 with AML has a mutation in the FLT3 gene. Several new drugs, called FLT3 inhibitors, target this gene. They have shown activity against AML in early studies, especially when combined with chemotherapy. So far, they are only available in clinical trials.

Other gene mutations, such as changes in the c-KIT gene, also appear to be important in some cases of AML, and may become important targets for new therapies. Drugs that target this gene, such as imatinib (Gleevec®) and dasatinib (Sprycel®) are already used against other types of leukemia, and are now being studied against AML.

Immunotherapy

Monoclonal antibodies 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. Other monoclonal antibodies have radioactive chemicals or cell poisons attached to them. When they are injected into the patient, the 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 lymphoma, but their use in leukemia has been more limited.

Gemtuzumab ozogamicin (Mylotarg®) is a monoclonal antibody with a cell poison attached that at one time was approved by the FDA to treat AML in older patients. Although it was taken off the market because it didn't seem very helpful, it is showing promise in certain patients in clinical trials.

Vaccine therapy: A study of an experimental vaccine had promising results. For this vaccine, 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, the cells induce other immune system cells to attack the patient's leukemia.

Additional resources for acute myeloid leukemia

More information from your American Cancer Society

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

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)

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

Understanding Cancer Surgery: A Guide for Patients and Families (also in Spanish)

Understanding Chemotherapy: A Guide for Patients and Families (also in Spanish)

Understanding Radiation Therapy: A Guide for Patients and Families (also in Spanish)

Targeted Therapy

Clinical Trials: What You Need to Know

Stem Cell Transplant (Peripheral Blood, Bone Marrow, and Cord Blood Transplants)

Cancer treatment side effects

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

Distress in People With Cancer

Anxiety, Fear, and Depression

Nausea and Vomiting

Pain Control: A Guide for People With Cancer and Their Families (also in Spanish)

Pain Diary

Anemia in People With Cancer

Fatigue in People With Cancer

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 telephone-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

Their "Cancer Information Service" 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.

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; telephone 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

American Cancer Society. *Cancer Facts & Figures 2014*. Atlanta, Ga: American Cancer Society; 2014.

Appelbaum FR. Acute myeloid leukemia in adults. In: Abeloff MD, Armitage JO, Niederhuber JE. Kastan MB, McKenna WG, eds. Abeloff's *Clinical Oncology*. 4th ed. Philadelphia, Pa: Elsevier; 2008:2215-2234.

Attar EC, Johnson JL, Amrein PC, et al. Bortezomib added to daunorubicin and cytarabine during induction therapy and to intermediate-dose cytarabine for consolidation in patients with previously untreated acute myeloid leukemia age 60 to 75 years: CALGB (Alliance) study 10502. *J Clin Oncol*. 2013;31(7):923-929. Epub 2012 Nov 5.

Burnett AK, Russell NH, Hills RK, et al. Addition of gemtuzumab ozogamicin to induction chemotherapy improves survival in older patients with acute myeloid leukemia. *J Clin Oncol*. 2012;30(32):3924-3931. Epub 2012 Jul 30.

Cashen AF, Schiller GJ, O'Donnell MR, DiPersio JF. Multicenter, phase II study of decitabine for the first-line treatment of older patients with acute myeloid leukemia. *J Clin Oncol*. 2010;28(4):556-561. Epub 2009 Dec 21.

Estey EH, Kantarjian HM. Therapy for acute myeloid leukemia. In: Hoffman R, Benz EJ, Shattil SJ, Furie B, Cohen HJ, Silberstein LE, McGlave P, eds. *Hematology: Basic Principles and Practice*. 4th ed. Philadelphia, Pa: Elsevier; 2005:1099-1120.

Fenaux P, Mufti GJ, Hellström-Lindberg E, et al. Azacitidine prolongs overall survival compared with conventional care regimens in elderly patients with low bone marrow blast count acute myeloid leukemia. *J Clin Oncol*. 2010;28(4):562-569. Epub 2009 Dec 21.

Gore SD, Gojo I, Sekeres MA, et al. Single cycle of arsenic trioxide-based consolidation chemotherapy spares anthracycline exposure in the primary management of acute promyelocytic leukemia. *J Clin Oncol*. 2010;28(6):1047-1053. Epub 2010 Jan 19.

Howlader N, Noone AM, Krapcho M, et al (eds). SEER Cancer Statistics Review, 1975-2009 (Vintage 2009 Populations), National Cancer Institute. Bethesda, MD, http://seer.cancer.gov/csr/1975_2009_pops09/, based on November 2011 SEER data submission, posted to the SEER website, April 2012.

Kantarjian HM, Erba HP, Claxton D, et al. Phase II study of clofarabine monotherapy in previously untreated older adults with acute myeloid leukemia and unfavorable prognostic factors. *J Clin Oncol*. 2010;28(4):549-555. Epub 2009 Dec 21.

Kantarjian H, Faderl S, Garcia-Manero G, et al. Oral sapacitabine for the treatment of acute myeloid leukaemia in elderly patients: a randomised phase 2 study. *Lancet Oncol*. 2012;13(11):1096-1104. Epub 2012 Oct 15.

Kebriaei P, Champlin R, de Lima M, Estey E. Management of acute leukemias. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. DeVita, Hellman, and Rosenberg's *Cancer: Principles and Practice of Oncology*. 9th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2011:1928-1954.

Klepin HD, Balducci L. Acute myelogenous leukemia in older adults. *Oncologist*. 2009;14:222-232.

Lo-Coco F, Avvisati G, Vignetti M, et al.Retinoic acid and arsenic trioxide for acute

promyelocytic leukemia. *N Engl J Med*. 2013 Jul 11;369(2):111-21.

Miller KB, Daoust PR. Clinical manifestations of acute myeloid leukemia. In: Hoffman R, Benz EJ, Shattil SJ, Furie B, Cohen HJ, Silberstein LE, McGlave P, eds. *Hematology: Basic Principles and Practice*. 4th ed. Philadelphia, Pa: Elsevier; 2005:1071-1098.

National Comprehensive Cancer Network. *NCCN Practice Guidelines in Oncology: Acute Myeloid Leukemia.* V.2.2013. Accessed at www.nccn.org on April 23, 2013.

National Cancer Institute. Physician Data Query (PDQ). *Adult Acute Myeloid Leukemia Treatment*. 2/12/2013. Accessed at www.cancer.gov/cancertopics/pdq/treatment/adultAML/healthprofessional on April 19, 2013.

National Toxicology Program. Final Report on Carcinogens Background Document for Formaldehyde. Rep Carcinog Backgr Doc. 2010 Jan;(10-5981):i-512.

O'Donnell MR. Acute leukemias. In: Pazdur R, Wagman LD, Camphausen KA, Hoskins WJ, eds. *Cancer Management: A Multidisciplinary Approach*. 11th ed. Lawrence, KS: CMPMedica; 2008:797-826.

Schiller GJ, O'Brien SM, Pigneux A, et al. Single-agent laromustine, a novel alkylating agent, has significant activity in older patients with previously untreated poor-risk acute myeloid leukemia. *J Clin Oncol*. 2010;28(5):815-821. Epub 2009 Dec 21.

Travis LB, Bhatia S, Allan JM, Oeffinger KC, Ng A. Second Primary Cancers. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. DeVita, Hellman, and Rosenberg's *Cancer: Principles and Practice of Oncology*. 9th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2011: 2393-2410.

Van Tendeloo VF, Van de Velde A, Van Driessche A, et al. Induction of complete and molecular remissions in acute myeloid leukemia by Wilms' tumor 1 antigen-targeted dendritic cell vaccination. *Proc Natl Acad Sci U S A*. 2010;107(31):13824-13829. Epub 2010 Jul 14.

Last Medical Review: 7/24/2013
Last Revised: 2/7/2014