Leukemia: Acute Myeloid (Myelogenous) Overview

What is acute myeloid leukemia?

Cancer starts when cells in a part of the body start to grow out of control. Cells in nearly any part of the body can become cancer. To learn more about what cancer is and how it starts, see What Is Cancer?

Leukemia is a type of cancer that starts in cells that form new blood cells. These cells are found in the soft, inner part of the bones called the bone marrow. There are many types of leukemia. Here we will talk about acute myeloid leukemia (AML).

Normal bone marrow and blood cells

To understand the different types of leukemia, it helps to know about the bone marrow and types of blood cells. Any blood-forming cell can turn into a leukemia cell. Once that happens, the cell can grow and divide to form many new cancer cells. These cells can take over the bone marrow, spill out into the bloodstream, and spread to other organs.

Bone marrow

Bone marrow is the soft, spongy, inner part of bones. It is found in some bones such as the skull, shoulder blades, ribs, pelvis, and backbones. All of the blood cells are made in the bone marrow. Bone marrow is made up of blood stem cells, blood-forming cells, fat cells, and tissues that help blood cells grow.

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

**Red blood cells** carry oxygen from the lungs to all other tissues of the body. They also carry away carbon dioxide, a cell waste product.

**White blood cells** help the body fight infections. There are many types of white blood cells. Each has a special role to play in protecting the body against infection. The main types of white blood cells are granulocytes, monocytes, and lymphocytes.

**Platelets** are actually pieces that break off from certain bone marrow cells. Platelets help stop bleeding by plugging up holes in blood vessels caused by cuts or bruises.

Acute myeloid leukemia

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

*Acute* means that this leukemia can grow quickly if not treated, and could be fatal in a few months. *Myeloid* refers to the type of cell this leukemia starts from.

AML is a cancer that starts in the cells that are supposed to mature into different types of blood cells (other than lymphocytes). AML starts in the bone marrow, 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 (in men).

In contrast, other types of cancer can start in these organs and then spread to the bone marrow (or other places). Those cancers are *not* leukemia.

AML isn’t the only kind of leukemia. There are other types as well. Knowing the exact type can help doctors better predict each patient's outlook (prognosis) and select the best treatment.

**This section contains information on AML in adults only.** To learn more about AML in children, see *Childhood Leukemia*. For information on other types of leukemia, see the leukemia section of our website.

What are the risk factors for acute myeloid leukemia?

A risk factor is something that affects a person’s chance of getting a disease such as cancer. Different cancers have different risk factors. Some risk factors, like smoking, can be controlled. Others, like a person’s age, can’t be changed.
But having a risk factor, or even many risk factors, does not mean that you will get the disease. And many people who get the disease may have few or no known risk factors. Even if a person has a risk factor and gets cancer, it’s often very hard to know how much that risk factor contributed to the cancer.

Risk factors for acute myeloid leukemia (AML)

There are some known risk factors for AML:

- Smoking
- Exposure to certain chemicals, such as benzene
- Being treated with certain chemotherapy drugs
- Exposure to high doses of radiation
- Certain blood diseases such as polycythemia vera, essential thrombocythemia, idiopathic myelofibrosis, and myelodysplastic syndrome
- Some genetic syndromes, such as Fanconi anemia, Bloom syndrome, ataxia-telangiectasia, Li-Fraumeni syndrome, and Down syndrome
- Family history of AML
- Older age
- Male gender

Some other factors have been studied for a possible link to AML, but so far these links haven’t been proven:

- 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

Can acute myeloid leukemia be prevented?

Most people who develop acute myeloid leukemia (AML) do not have any risk factors that can be avoided. Most cases of AML have no clear cause. Since the cause is not known, there is no way to prevent most of these leukemias.

Smoking is by far the most important risk factor that can be controlled, 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 get many other cancers, as well as heart disease, stroke, and other diseases.

Treatment of other cancers with chemotherapy and radiation may cause secondary (after treatment) leukemias. Doctors are trying to figure out ways to treat these cancers without raising their risk of getting leukemia later on. But for now, the real need to treat cancers with chemotherapy and radiation must be balanced against the small chance of getting leukemia years later.

Avoiding known cancer-causing industrial chemicals, such as benzene, can lower the risk of getting AML. But most experts agree that only a small number of leukemia cases are linked to these chemicals.

**Signs and symptoms of acute myeloid leukemia**

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

**General symptoms**

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

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

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

**Symptoms from low numbers of normal blood cells**

Many signs and symptoms of AML come 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, but they can also cause symptoms.
Symptoms from a shortage of red blood cells (anemia): Red blood cells carry oxygen to all of the cells in the body. A shortage of red blood cells can cause:

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

Symptoms from a shortage of normal white blood cells: Not having enough normal white blood cells can increase the risk of infection. Fevers and other signs of infection are common symptoms.

Symptoms from a shortage of blood platelets: Not having enough blood platelets can lead to:

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

Symptoms from high numbers of leukemia cells

AML cancer cells are bigger than normal white blood cells and have more trouble going through tiny blood vessels. These cells can clog up blood vessels, which can affect normal blood flow to the brain, leading to symptoms like those seen with a stroke, such as:

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

The cancer cells can also affect normal blood flow to other organs, such as the lungs (leading to problems with shortness of breath) or the eyes (leading to blurry vision or even loss of vision).
These problems are rare, but they need to be treated right away.

**Bleeding and clotting problems**

Patients with a certain type of AML called *acute promyelocytic leukemia* (APL) may have bleeding and clotting problems. 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 people have pain caused by the build-up of leukemia cells in bones or joints.

**Swelling in the belly**

Leukemia can also cause swelling of the liver and spleen. This may be noticed as a fullness or swelling of the belly.

**Spread to the skin**

If leukemia cells spread to the skin, they can cause lumps or spots that may look like common rashes.

**Spread to the gums**

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

**Spread to other organs**

Sometimes, leukemia cells spread to other organs. If it spreads to the brain and spinal cord it can cause:

- Headaches
- Weakness
- Seizures
- Vomiting
- Trouble with balance
- Numbness on the face
- Blurred vision
Rarely, AML can spread to the eyes, testicles, kidneys, or other organs.

**Enlarged lymph nodes**

AML rarely spreads to lymph nodes. Nodes in the neck, groin, under arms, or above the collarbone may swell and be felt as lumps under the skin.

**How is acute myeloid leukemia found?**

At this time, there are no special tests that can find acute myeloid leukemia (AML) early. Report any possible symptoms of AML to your doctor right away.

People known to have a higher risk of AML because they have certain blood problems or syndromes or because they were treated with certain chemotherapy drugs or radiation should have careful, regular medical checkups. They do not usually get leukemia, but they and their doctors should be aware of the possible symptoms of AML.

**Medical history and physical exam**

Most of the symptoms seen in leukemia can also be caused by other problems like infections. If signs or symptoms suggest you might have leukemia, the doctor will want to ask you questions about your health (get a medical history), such as how long you have had symptoms and whether or not you have any risk factors.

The doctor will likely do a physical exam to look for any enlarged lymph nodes, bleeding or bruising, or signs of infection. If there seems to be a problem with blood cell counts, blood tests will be done. If the results suggest leukemia, your doctor may refer you to a cancer doctor (an oncologist) or a blood doctor (a hematologist), who may do one or more of the tests described below.

**Types of samples used to test for AML**

The doctor will need to check samples of cells from your blood and bone marrow confirm that you have leukemia. Other tissue and cell samples may also be taken to help guide treatment.

**Blood samples**

Blood samples to check for AML are most often taken from a vein in the arm.
Bone marrow samples

Bone marrow samples are taken through procedures called bone marrow aspiration and biopsy. These are 2 tests, but they are done together. In bone marrow aspiration, a thin needle and syringe is used to take out a small amount of liquid bone marrow. During a bone marrow biopsy, a small cylinder of bone and marrow is removed with a slightly larger needle.

Both samples are usually taken at the same time from the back of the hipbone (but sometimes other bones are used instead). The area is numbed before the samples are taken, but most people still have some brief pain during these tests.

These tests are used to tell whether leukemia is present. If you are having treatment, they can also be used to see how well treatment is working.

Spinal fluid

A test called a spinal tap (lumbar puncture) might be done to look for leukemia cells in the fluid around the brain and spinal cord (cerebrospinal fluid or CSF). The doctor first numbs a place in the lower part of the back over the spine. A small needle is placed between the bones of the spine in the lower back to draw out some of the fluid. The fluid is looked at for leukemia cells.

This test is not usually done for people with AML. It may be done if the doctor suspects that the leukemia has spread to the CSF based on certain symptoms. It can also be used to put chemo into the CSF if the leukemia has already spread there.

Lab tests

One or more of these lab tests may be done on the samples to tell if you have AML and to learn the exact type.

Blood cell counts and exams

Changes in the numbers of different blood cell types and how the cells look under a microscope can suggest leukemia. Most people with AML will have too many white blood cells and not enough red blood cells or platelets. Also, many of the white cells will be blasts, a type of immature cell not normally found in the blood. These cells don’t work the way they should.

People already known to have leukemia will have tests done to measure the amount of certain chemicals in the blood. These tests can help tell how well their kidneys and liver are working and if the blood is clotting as it should.
A doctor looks at the biopsy samples (bone marrow, blood, and cerebrospinal fluid) under a microscope. The doctor looks at the size and shape of the cells as well as other features to classify the cells into different types. An important goal of this process is to see whether the cells look mature. The number of blasts (immature cells) in the bone marrow is important in telling whether a person has leukemia.

**Other lab tests**

Other special tests can be used to look at the samples to help the doctor decide which type of leukemia a person has. You might hear some of the following terms:

- Cytochemistry
- Flow cytometry
- Immunohistochemistry (IHC)
- Cytogenetics
- FISH
- PCR

These are complex medical and chemical tests. Your doctor can tell you which of these might need to be done and why.

**Imaging tests**

Imaging tests are ways of taking pictures of the inside of the body. Some of these tests might be done in people with leukemia. They are done most often to look for infections or other problems rather than to look for the leukemia itself.

**X-rays**

Regular x-rays are not often needed in AML, but a chest x-ray might be done if the doctor thinks there could be a lung infection.

**CT (computed tomography) scan**

A CT scan uses x-rays to make detailed pictures of the inside of your body. This test can help tell whether any lymph nodes or organs in your body are swollen. This test is not often needed in people with AML.
MRI (magnetic resonance imaging) scan

Like CT scans, MRI scans make detailed pictures of soft tissues in the body. But MRI scans use radio waves and strong magnets instead of x-rays. MRI scans help look at the brain and spinal cord. But they are not often needed in people with AML.

Ultrasound

Ultrasound uses sound waves to make pictures of organs inside your body. It can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside your belly, such as the kidneys, liver, and spleen.

How is acute myeloid leukemia classified?

For most types of cancer, figuring out the stage (extent) of the cancer is very important. The stage is based on the size of the tumor and how far it has spread. But leukemia is not staged this way because it does not usually form a tumor. It already involves all the bone marrow and, in many cases, it has also spread to other organs. So the outlook for the patient with acute myeloid leukemia (AML) depends on other things, such as the exact type of AML, the age of the patient, and lab test results.

Classification systems

Two systems have been used to classify AML into subtypes: the French-American-British (FAB) system and the newer World Health Organization (WHO) system.

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

In the 1970s, a group of French, American, and British leukemia experts divided AML into subtypes, M0 through M7, based on the type of cell from which the leukemia started and how mature the cells are. This system is based largely on how the leukemia cells looked under the microscope. But now doctors use many advanced gene tests to classify AML.

World Health Organization (WHO) Classification of AML

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

In recent years, research has focused on why some patients have a better chance to be cured than others. Differences among patients that affect how they respond to treatment are called *prognostic factors*. These factors include:

- The patient’s age
- White blood cell count
- Whether the leukemia cells have certain gene or chromosome changes
- Whether the person had a blood disorder before the AML
- Whether the person had chemotherapy or radiation in the past to treat another cancer
- Whether the AML has reached the brain and spinal cord
- How well and (how quickly) the AML responds to treatment

If you would like more details about these prognostic factors, see *Leukemia: Acute Myeloid (Myelogenous)*.

How is acute myeloid leukemia treated?

About treatment

Acute myeloid leukemia (AML) is not just one disease. It is really a group of diseases, and people with different subtypes vary in how they respond to treatment.

Once AML has been diagnosed, your cancer care team will discuss your treatment options with you. Treatment options are based on the subtype of AML as well as on certain prognostic features. Several different types of treatment may be used in people with AML. The major treatment is chemotherapy, sometimes followed by a stem cell transplant. Other drugs (besides standard chemotherapy drugs) may also be used to treat people with the acute promyelocytic leukemia (APL) subtype of AML. Surgery and radiation treatment may be used in special cases.

It’s important to discuss your treatment options and their possible side effects with your doctors to help make the decision that best fits your needs. It’s also very important to ask questions if there is anything you’re not sure about. For a list of questions to ask, see “What are some questions I should ask my doctor about acute myeloid leukemia?”

In most cases AML can grow quickly, so it’s important to start treatment as soon as possible.
Thinking about taking part in a clinical trial

Clinical trials are carefully controlled research studies that are done to get a closer look at promising new treatments or procedures. 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 best way for doctors to learn better methods to treat cancer. Still, they are not right for everyone.

If you would like to learn more about clinical trials that might be right for you, start by asking your doctor if your clinic or hospital conducts clinical trials. You can also call our clinical trials matching service at 1-800-303-5691 for a list of studies that meet your medical needs, or see the Clinical Trials section to learn more.

Considering complementary and alternative methods

You may hear about alternative or complementary methods that your doctor hasn’t mentioned to treat your cancer or relieve symptoms. These methods can include vitamins, herbs, and special diets, or other methods such as acupuncture or massage, to name a few.

Complementary methods refer to treatments that are used along with your regular medical care. Alternative treatments are used instead of a doctor’s medical treatment. Although some of these methods might be helpful in relieving symptoms or helping you feel better, many have not been proven to work. Some might even be dangerous.

Be sure to talk to your cancer care team about any method you are thinking about using. They can help you learn what is known (or not known) about the method, which can help you make an informed decision. See the Complementary and Alternative Medicine section to learn more.

Help getting through cancer treatment

Your cancer care team will be your first source of information and support, but there are other resources for help when you need it. Hospital- or clinic-based support services are an important part of your care. These might include nursing or social work services, financial aid, nutritional advice, rehab, or spiritual help.

The American Cancer Society also has programs and services – including rides to treatment, lodging, support groups, and more – to help you get through treatment. Call our National Cancer Information Center at 1-800-227-2345 and speak with one of our trained specialists on call 24 hours a day, every day.

The treatment information given here is not official policy of the American Cancer 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.
Chemotherapy for acute myeloid leukemia

Chemotherapy (chemo) is the use of drugs to kill cancer cells. Usually the drugs are given into a vein or by mouth. These drugs enter the bloodstream and go throughout the body. If leukemia cells are found in the fluid around the brain and spinal cord (CSF), the drugs may be given directly into the CSF. This isn’t common in the treatment of acute myeloid leukemia (AML).

Chemo is the main treatment for most people with AML.

Treatment of AML is typically divided into 2 phases:

- **Induction (or remission induction):** The goal of this first phase is to clear the blood of leukemia cells (blasts) and to reduce the number of blasts in the bone marrow to normal. It usually involves treatment with 2 or 3 chemo drugs that are given while the patient is in the hospital. It takes about a week to give the chemo, and then often the patient stays in the hospital for a few weeks longer. In rare cases where the leukemia has spread to the brain or spinal cord, chemo may be given into the CSF as well.

- **Consolidation (post-remission):** The purpose of this second phase is to kill any remaining leukemia cells and keep the AML from coming back (relapsing). The options for consolidation treatment are either more chemo or a stem cell transplant.

For the acute promyelocytic leukemia (APL) subtype of AML, there is a third phase:

- **Maintenance:** This involves giving low doses of chemo drugs (or other drugs) for months or years after consolidation is finished.

**Treating frail, older adults**

People who are elderly or are in poor health may not be able to get intense chemo. In fact, it might actually shorten their lives. In some cases, doctors may recommend less intense treatment. 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 more often used to treat another disease called myelodysplastic syndrome, which might have fewer side effects.

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

**Side effects of chemo**

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

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

- Hair loss
- Mouth sores
- Loss of appetite
- Nausea and vomiting
- Diarrhea or constipation
- Greater chance of infection (due to a shortage of normal white blood cells)
- Easy bruising or bleeding (due to a shortage of blood platelets)
- Tiredness (due to a shortage of red blood cells)

Most of these side effects go away after treatment ends. And there are often ways to manage these side effects during treatment. For example, drugs can be taken along with the chemo to prevent or reduce nausea and vomiting.

If your white blood cell counts are very low during treatment, it increases your risk of serious infection. Your doctor may tell you to take special steps to avoid germs. Antibiotics are often given before there are signs of infection or as soon as it looks like one may be starting.

If your platelet counts are low, you might get platelet transfusions to help prevent bleeding. Low red blood cell counts, causing shortness of breath and tiredness, can be treated with drugs or with transfusions.

**Tumor lysis syndrome** is a side effect caused by the rapid breakdown of leukemia cells during treatment. It is most common during the first treatment (induction), when the patient has the highest numbers of leukemia cells. When these cells die, they break open and release their contents into the bloodstream, which can affect the kidneys, heart, and nervous system. Extra fluids or certain drugs that help rid the body of these substances can help prevent this problem.

Organs that could be damaged by chemo include the kidneys, liver, testicles, ovaries, brain, heart, and lungs. By watching the patient carefully, the doctor may be able to limit many of these side effects. If serious side effects happen, though, the chemo drugs may have to be given at lower doses or even stopped. Be sure to tell your doctor about any problems you have.
For more details about the treatment of AML, see *Leukemia–Acute Myeloid (Myelogenous)*.

**Drugs other than chemo for acute myeloid leukemia**

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

Researchers have found 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:

- All-trans-retinoic acid (ATRA, tretinoin, or Vesnoid®)
- Arsenic trioxide (ATO, Trisenox®)

These drugs are used for APL, but they are not helpful for any other type of AML. One or both of these drugs may be used as a part of the treatment of APL.

**Side effects**

These drugs can cause *differentiation syndrome*, most often during the first treatment cycle. Symptoms include breathing problems from 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.

ATRA can also have other side effects, such as:

- Headache
- Fever
- Dry skin and mouth
- Skin rash
- Swollen feet
- Sores in the mouth or throat
- Irritated eyes
- Higher blood lipid levels (like those of cholesterol and triglycerides)

These side effects often go away when the drug is stopped.

Most side effects of arsenic trioxide are mild and can include:
• Tiredness
• Nausea and vomiting
• Diarrhea
• Belly pain
• Nerve damage leading to numbness and tingling in the hands and feet
• Problems with heart rhythm. Your doctor may check your EKG often (even daily) while you are getting this drug.

More information about these drugs and the treatment of APL can be found in *Leukemia–Acute Myeloid (Myelogenous).*

**Surgery for acute myeloid leukemia**

Surgery plays a very small part in the treatment of leukemia. Because leukemia is a disease of blood and bone marrow, it’s not possible to cure it with surgery.

But surgery may be used to help deliver treatment. A plastic tube called a a *central venous catheter* (CVC) or *venous access device* can be put into a large vein. The tube allows chemo drugs or other medicines to be given and blood samples to be taken. This lessens the number of needle sticks needed during treatment. The patient must learn how to take care of the device to keep it from getting infected.

**Radiation therapy for acute myeloid leukemia**

Radiation treatment is the use of high-energy x-rays to kill cancer cells. It is not often part of the main treatment for acute myeloid leukemia (AML), but there are a few times in which it may be used:

• It is sometimes used to treat leukemia that has spread to the brain and spinal fluid or to the testicles.

• Radiation to the whole body is often an important part of treatment before a stem cell transplant.

• It is used (rarely) to help shrink a tumor if it is pressing on the windpipe and causing breathing problems. But chemo is often used instead since it often works more quickly.

• Radiation can be used to reduce pain in a bone that has leukemia in it, if chemo hasn’t helped.
The possible side effects of radiation depend on where it is aimed. Sunburn-like skin changes in the treated area can happen. Radiation to the head and neck area can lead to mouth sores and trouble swallowing. Radiation to the belly can sometimes cause nausea, vomiting, or diarrhea. If large areas of the body get radiation, the effects may include tiredness, bleeding or bruising easily, and an increased risk of infection.

**Stem cell transplant for acute myeloid leukemia**

Very high doses of chemo drugs might work better to kill cancer cells, but the damage to the bone marrow (where new blood cells are made) could be fatal. A stem cell transplant (SCT) is a way for doctors to use high doses of chemo. The drugs destroy the patient’s bone marrow, but the transplanted stem cells restore it.

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

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

- **An allogeneic transplant** is the most common form of SCT used to treat acute myeloid leukemia (AML). For this, the stem cells come from a donor whose tissue matches the patient’s – often a close relative, like a brother or sister. Sometimes umbilical cord stem cells are used.

- **In an autologous transplant**, a patient’s own stem cells are removed from the blood or bone marrow. They are frozen and stored while the person gets strong chemo and perhaps radiation. The stem cells are then given back to the patient after treatment.

There is a good reason to use stem cells from someone else for the transplant. These cells seem to help fight any remaining leukemia cells through an immune reaction. This is called a *graft-versus-leukemia* reaction. Also, the patient’s own stem cells may contain some leukemia cells, even if they are collected when the leukemia is in remission.

**Mini-transplant**

Most older patients can’t have a regular allogeneic SCT that uses high doses of chemo. Some may be able to have what is called a *mini-transplant* (also called a *non-myeloablative transplant or reduced-intensity transplant*), where they get lower doses of chemo and radiation that do not destroy the all cells in their bone marrow. They then are given the donor stem cells. These cells enter the body and form a new immune system, which sees the leukemia cells as foreign and attacks them (a *graft-versus-leukemia* effect). This is not the standard type of transplant used for AML, and some doctors still think of this approach as experimental in this disease.
Some things to keep in mind

A stem cell transplant (SCT) is a complex treatment that can sometimes cause life-threatening side effects. If the doctors think you might be helped by this treatment, it is important that it be done at a hospital where the staff has experience.

SCT can cost more than $100,000 and might mean a long hospital stay. Because certain types of SCT may be seen as experimental by insurance companies, they might not pay for it. You should find out what your insurance will cover and what you might have to pay before deciding on a transplant.

Side effects of stem cell transplant

Common side effects are from the high doses of chemo and can be severe. These include nausea and vomiting, mouth sores, hair loss, and very low blood counts. One of the most common and serious short-term effects is the greater risk of infection caused by low white blood cell counts. Antibiotics are often given to try to prevent this. You might need to stay in a special hospital room to lower your exposure to germs until your immune system has recovered. Other side effects, like low red blood cell and platelet counts, might mean you will need transfusions.

**Graft-versus-host-disease (GVHD):** This is one of the most serious side effects from allogeneic SCTs. It happens when the patient’s immune system is taken over by that of the donor. The donor immune system then attacks the patient’s other tissues and organs.

Symptoms can include bad skin rashes with itching, mouth sores, nausea, and severe diarrhea. The liver and lungs may also be damaged. The patient may also be very tired and have aching muscles. If bad enough, GVHD can be fatal.

Drugs that weaken the immune system may be given to try to control it.

**Long-term side effects:** Stem cell transplants can also have some long-term side effects, including:

- Loss of fertility
- Damage to the lungs, causing shortness of breath
- Damage to the thyroid gland
- Cataracts (damage to the lens of the eye that can affect vision)
- Bone damage from poor blood supply. If damage is severe, the patient might need to have part of the bone and the joint replaced.
- Developing another cancer years later
To learn more about stem cell transplants, see *Stem Cell Transplant (Peripheral Blood, Bone Marrow, and Cord Blood Transplants).*

**What are some questions I should ask my doctor about acute myeloid leukemia?**

It’s important to have honest, open talks with your doctor. Feel free to ask any question that’s on your mind, no matter how small it might seem. Here are some questions you might want to ask.

- Would you please write down the exact type of leukemia I have?
- Are there any specific factors that might affect my outlook?
- Do I need other tests before we can decide on treatment?
- Do I need to see any other doctors?
- How much experience do you and this medical center have treating this type of cancer?
- Should I get a second opinion?
- What are my treatment choices?
- Which treatment do you recommend, and why?
- What are the risks and side effects of treatment?
- What can 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 can I do to help reduce the side effects I may have from the chemo?
- Should we think about a stem cell transplant? If so, when?
- What is the outlook for my survival?
- 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 to know more about recovery times. Or you might want to ask about clinical trials. Taking another person and/or a tape recorder to your appointments can be helpful.
Keep in mind, too, that doctors aren’t the only ones who can give you information. Other health care professionals, such as nurses and social workers, might be able to answer some of your questions. You can find out more about speaking with your health care team in *Talking With Your Doctor*.

**Moving on after treatment for acute myeloid leukemia**

For some people with acute myeloid leukemia (AML), treatment can destroy the leukemia. It can feel good to be done with treatment, but it can also be stressful. You might find that you now worry about the cancer coming back. This is a very common concern among those who have had cancer. (When cancer comes back, it is called a recurrence.)

It may take a while before your recovery begins to feel real and your fears are somewhat relieved. You can learn more about what to look for and how to learn to live with the chance of cancer coming back in *Living With Uncertainty: The Fear of Cancer Recurrence*.

For some people, the leukemia may never go away completely. These people may get regular treatments to try to keep the leukemia under control and help relieve symptoms from it. Learning to live with leukemia that does not go away can be hard. It has its own type of uncertainty. See *When Cancer Doesn’t Go Away* for more about this.

**Follow-up care**

Treatment for AML can last for months or years. Even after treatment ends, you will need frequent follow-up exams – probably every few months for several years. It’s very important to go to all follow-up appointments. During these visits, your doctors will ask about symptoms, examine you, and get blood tests or bone marrow tests.

If the leukemia comes back, it usually does so while you are still being treated or shortly after chemo is finished. But it is unusual for AML to return if there are no signs of the disease a few years after treatment.

Should your cancer come back, see *When Your Cancer Comes Back: Cancer Recurrence* for information to help you manage and cope with this phase of your treatment.

Almost any cancer treatment can have side effects. Some may last for a short time, but others can be permanent. Tell your cancer care team about any symptoms or side effects that bother you so they can help you manage them.

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

At some point after your treatment, you may be seeing a new doctor. It’s important to be able to give your new doctor the details of your diagnosis and treatment. Gathering these details soon after treatment may be easier than trying to get them at some point in the future. Make sure you have this information handy (and always keep copies for yourself):

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

Lifestyle changes after treatment for acute myeloid leukemia

Having cancer and dealing with treatment can take a lot of time and energy, but it can also 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.

Make healthier choices

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

You can start by working on those things that worry you most. Get help with those that are harder for you. For instance, if you are thinking about quitting smoking and need help, call us at 1-800-227-2345.

Eating better

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

If treatment causes weight changes or eating or taste problems, do the best you can and keep in mind that these problems usually get better over time. You may find it helps to eat small meals 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 treatment is to practice healthy eating habits. You may be surprised at the long-term benefits of some simple changes. Getting to and staying at a healthy weight, eating a healthy diet, and limiting your alcohol intake can lower your risk for a number of types of cancer, as well as having many other health benefits.

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

**Fatigue and exercise**

Feeling tired (fatigue) is a very common problem during and after cancer treatment. This is not a normal type of tiredness but a bone-weary exhaustion that often doesn’t get better with rest. For some people, fatigue lasts a long time after treatment and can keep them from staying active. But exercise can actually help reduce fatigue and the sense of depression that sometimes comes with feeling so tired.

If you are very tired, though, you will need to balance activity with rest. It’s OK to rest when you need to. To learn more about fatigue, see Fatigue in People With Cancer and Anemia in People With Cancer.

If you were very ill or weren't able to do much during treatment, it is normal that your fitness, staying power, and muscle strength declined. You need to find an exercise plan that fits your own needs. Talk with your health care team before starting. Get their input on your plans. Then try to get an exercise buddy so that you're not doing it alone.

Exercise can improve your physical and emotional health.

- It improves your heart fitness.
- It can help you get to and stay at a healthy weight.
- It makes your muscles stronger.
- It reduces fatigue.
- It can help lower anxiety and depression.
- It can make you feel generally happier.
• It helps you feel better about yourself.

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

**Can I lower my risk of AML progressing or coming back?**

Most people want to know what they can do to reduce their risk of cancer progressing or coming back. Unfortunately, for the most part this is an area that hasn’t been well studied. Most studies have looked at lifestyle changes as ways of preventing cancer in the first place, not slowing it down or preventing it from coming back.

At this time, not enough is known about AML to say for sure if there are things you can do that will help. Healthy behaviors such as not smoking, eating well, and staying at a healthy weight might help, but no one knows for sure.

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

**How about your emotional health after acute myeloid leukemia?**

Once your treatment ends, you may be surprised by the flood of emotions you go through. This happens to a lot of people.

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

This is a good time to look for emotional and social support. You need people you can turn to. Support can come in many forms: family, friends, cancer support groups, religious or spiritual groups, online support communities, or private counselors.

The cancer journey can feel very lonely. You don’t need to go it alone. Your friends and family may feel shut out if you decide not to include them. Let them in – and let in anyone else who 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

When a person has had many different treatments and the cancer has not been cured, even newer treatments may no longer be helpful. At this time you may have to weigh the possible benefits of a new treatment against the downsides, like treatment side effects.

This is likely to be the hardest time in your battle with cancer – when you have tried everything within reason and it’s just not working anymore. Your doctor might offer you new treatment, but you will need to talk about whether the treatment is likely to improve your health or change your outlook for survival.

Palliative care

No matter what you decide to do, it is important for you to feel as good as possible. Make sure you are asking for and getting treatment for pain, nausea, or any other problems you may have. This type of treatment is called *palliative treatment*. It helps relieve symptoms but is not meant to cure the cancer.

Hospice care

At some point you may want to think about hospice care. Most of the time this is given at home. Your cancer may be causing symptoms or problems that need to be treated. Hospice focuses on your comfort. You should know that having hospice care doesn’t mean you can’t have treatment for the problems caused by your cancer or other health issues. It just means that the purpose of your care is to help you live life as fully as possible and to feel as well as you can. You can learn more about this in *Hospice Care*.

Staying hopeful is important, too. Your hope for a cure may not be as bright, but there is still hope for good times with family and friends – times that are filled with joy and meaning. Pausing at this time in your cancer treatment gives you a chance to focus 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.

To learn more

You can learn more about the changes that occur when treatment stops working, and about planning ahead for yourself and your family, in *Advance Directives* and *Nearing the End of Life*. 
What’s new in acute myeloid leukemia research?

Research into the causes, diagnosis, and treatment of leukemia is going on at many medical centers, hospitals, and other places.

**Genetics of leukemia**

Scientists are making great progress in learning how changes in the DNA in normal bone marrow cells can change them into leukemia cells. Doctors are now learning how to use these changes to help them predict a person’s outlook and figure out whether they need more or less intense treatment. In the future, this information may be used to develop newer targeted treatments against acute myeloid leukemia (AML).

**Finding “hidden” disease (minimal residual disease)**

Progress has also been made in finding leukemia cells after treatment, when there are so few leukemia cells that they can’t be found by routine bone marrow tests. A test called PCR (polymerase chain reaction) can find even very small numbers of leukemia cells. This is helpful in seeing how well the chemo has destroyed the leukemia and whether it is likely that the cancer will come back (relapse).

Doctors are also trying to figure out what effect hidden disease has on a patient’s outlook, and how this might affect the need for more treatment.

**Better chemo**

Studies are going on to find the best combination of chemo drugs, with fewer side effects, and to figure out which patients will benefit the most from different types of treatment.

Sometimes chemo may not work very well 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.

**Stem cell transplants**

Studies are also being done to improve the stem cell transplant process and to predict which patients are most likely to be helped by this treatment. Many studies are also trying to help figure exactly which type of transplants might be best.
Targeted therapies

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

Immunotherapy

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

Monoclonal antibodies are man-made versions of immune system proteins (antibodies) that are designed to attach to certain targets, such as substances on the surface of leukemia cells. Some of these antibodies have radioactive chemicals or cell poisons attached to them so that when they are injected into the patient, they lock onto the cancer cells and kill them. One such antibody (gemtuzumab ozogamicin or Mylotarg®) was at one time was approved to treat AML in older patients. Although it was taken off the market because it didn’t seem very helpful, it is again 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. These cells are then given back to the patient into a vein (IV). In the body, the cells cause other immune system cells to attack the patient’s leukemia.

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

This technique has shown very promising results in early studies against some hard-to-treat types of lymphocytic leukemias. Although it’s not yet clear if it will work against AML, this is now being studied.

More information about acute myeloid leukemia

We have a lot more information that you might find helpful. Explore www.cancer.org or call our National Cancer Information Center toll-free number, 1-800-227-2345. We’re here to help you any time, day or night.
National organizations and websites*

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

**Acute myeloid leukemia**

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

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

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

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

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

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

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

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

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

Programs and services include: information and referrals to meet a wide range of needs; support via one-on-one conversations with trained peer support volunteers who are transplant survivors, caregivers, and donors; 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 to 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.

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