About Acute Myeloid Leukemia (AML)

Overview of AML

If you have been diagnosed with acute myeloid leukemia or are worried about it, you likely have a lot of questions. Learning some basics is a good place to start.

- What Is Acute Myeloid Leukemia?

Research and Statistics

See the latest estimates for new cases of acute myeloid leukemia and deaths in the US and what research is currently being done.

- Key Statistics for Acute Myeloid Leukemia
- What’s New in Acute Myeloid Leukemia Research and Treatment?

What Is Acute Myeloid Leukemia?

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

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

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

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

Most cases of AML develop from cells that would turn into white blood cells (other than lymphocytes), but some cases of AML develop in other types of blood-forming cells. The different types of AML are listed in How is Acute Myeloid Leukemia Classified?

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

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

**Normal bone marrow, blood, and lymphoid tissue**

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

**Bone marrow**

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

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

**Types of blood cells**

**Red blood cells** carry oxygen from the lungs to all other tissues in the body, and take carbon dioxide back to the lungs to be removed. Having too few red blood cells in the body (called *anemia*) can make you feel tired, weak, and short of breath because your body tissues are not getting enough oxygen.
Platelets are actually cell fragments made by a type of bone marrow cell called the megakaryocyte. Platelets are important in stopping bleeding. They help plug up holes in blood vessels caused by cuts or bruises. Having too few platelets (called thrombocytopenia) may cause you to bleed or bruise easily.

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

Types of white blood cells

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

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

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

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

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

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

Acute leukemia versus chronic leukemia

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

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

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

Myeloid leukemia versus lymphocytic leukemia

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

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

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

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

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

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

- References

See all references for Acute Myeloid Leukemia

Key Statistics for Acute Myeloid Leukemia

The American Cancer Society’s estimates for leukemia in the United States for 2018 are:

- About 60,300 new cases of leukemia (all kinds) and 24,370 deaths from leukemia (all kinds)
- About 19,520 new cases of acute myeloid leukemia (AML). Most will be in adults.
- About 10,670 deaths from AML. Almost all will be in adults.

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

AML is slightly more common among men than among women, but the average lifetime risk in both sexes is less than ½ of 1%.

Information on treatment success rates for AML in adults can be found in Treatment
response rates for acute myeloid leukemia.

Visit the American Cancer Society’s Cancer Statistics Center for more key statistics.

- References
See all references for Acute Myeloid Leukemia


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What’s New in Acute Myeloid Leukemia Research and Treatment?

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

Genetics of leukemia

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

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

**Detecting minimal residual disease**

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

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

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

**Improving treatment**

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

**Chemotherapy**

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

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

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

**Treating acute promyelocytic leukemia (APL)**

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

**Stem cell transplants**

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

**Targeted therapies**

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

In about 1 person out of 3 with AML, the leukemia cells have a mutation in the *FLT3* gene. New drugs called **FLT3 inhibitors**, such as midostaurin (Rydapt), target cells with this gene change. This drug is now approved for use along with chemotherapy to treat people whose AML has an *FLT3* mutation. Other drugs, such as quizartinib, have also shown activity against AML in early studies, especially when combined with chemotherapy. But so far, these other drugs are only available in clinical trials.

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

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

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

### Immunotherapy

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

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

**Gemtuzumab ozogamicin (Mylotarg)** is a monoclonal antibody with a cell poison attached to it. It is now approved to treat AML in some patients, after showing promise in clinical trials.

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

**Vaccine therapy:** Scientists are studying ways to boost the immune reaction against leukemia cells by using vaccines. For example, in one vaccine, certain types of white blood cells (cells of the immune system) are removed from the patient’s blood and exposed to a protein found on many AML cells called Wilms’ tumor 1 protein (WT1). These cells are then given back to the patient by infusion into a vein (IV). In the body, these cells help other immune system cells to attack the leukemia. An early study of this vaccine showed promising results, but more research is needed to see if it will be useful. Other vaccines are being studied as well.
**CAR T-cell therapy:** This is a promising new way to get the immune system to fight leukemia. For this technique, immune cells called *T cells* are removed from the patient’s blood and altered in the lab so they have specific substances (called *chimeric antigen receptors*, or CARs) that will help them attach to leukemia cells. The T cells are then grown in the lab and infused back into the patient’s blood, where they can now seek out the leukemia cells and attack them.

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

- References
  See all references for Acute Myeloid Leukemia

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