



Early Detection, Diagnosis, and Types

Detection and Diagnosis

Catching cancer early often allows for more treatment options. Some early cancers may have signs and symptoms that can be noticed, but that is not always the case.

- [Can Childhood Leukemia Be Found Early?](#)
- [Signs and Symptoms of Childhood Leukemia](#)
- [How Is Childhood Leukemia Diagnosed?](#)

Types and Outlook (Prognosis)

Learn how childhood leukemia is classified and how this may affect your treatment options.

- [How Is Childhood Leukemia Classified?](#)
- [Prognostic Factors in Childhood Leukemia \(ALL or AML\)](#)
- [Survival Rates for Childhood Leukemias](#)

Questions to Ask about Childhood Leukemia

Here are some questions to ask your cancer care team to help you better understand a childhood leukemia diagnosis and treatment options.

- [What Should You Ask Your Child's Doctor About Childhood Leukemia?](#)

Can Childhood Leukemia Be Found Early?

At this time there are no widely recommended blood tests or other screening tests for

most children to look for leukemia before it starts to cause symptoms. Childhood leukemia is often found because a child has symptoms that prompt a visit to the doctor. The doctor then orders blood tests, which come back as abnormal and point to the [diagnosis](#). The best way to find these leukemias early is to pay attention to the possible signs and symptoms of this disease (see [Signs and Symptoms of Childhood Leukemia](#)).

For children known to be at [increased risk of leukemia](#) (because of Li-Fraumeni syndrome or Down syndrome, for example), most doctors recommend careful, regular medical checkups and possibly other tests. The same is true for children who have been treated with chemotherapy and/or radiation therapy for other cancers, and for children who have had organ transplants and are taking immune system-suppressing drugs. The risk of leukemia in these children, although higher than in the general population, is still small.

- [References](#)

[See all references for Leukemia in Children](#)

Last Medical Review: April 17, 2015 Last Revised: February 3, 2016

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Signs and Symptoms of Childhood Leukemia

Many of the symptoms of childhood leukemia can have other causes as well, and most often these symptoms are not caused by leukemia. Still, if your child has any of them, it's important to have your child seen by a doctor so the cause can be found and treated, if needed.

The symptoms of leukemia are often caused by problems in the child's bone marrow, which is where the leukemia begins. As leukemia cells build up in the marrow, they can crowd out the normal blood cell-making cells. As a result, a child may 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. The leukemia cells might also invade other areas of the body, which can also cause symptoms.

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

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

Symptoms from low white blood cell counts:

- Infections can occur because of a shortage of normal white blood cells. Children with leukemia can get infections that don't seem to go away or may get one infection after another. Although children with leukemia often have high white blood cell counts because they have so many leukemia cells, these cells don't protect against infection the way normal white blood cells do.
- Fever is often the main sign of infection. But some children might have a fever without having an infection.

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

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

Bone or joint pain: This pain is caused by the buildup of leukemia cells near the surface of the bone or inside the joint.

Swelling of the abdomen (belly): Leukemia cells can collect in the liver and spleen, making them bigger. This might 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 often feel them.

Loss of appetite and weight loss: If the spleen and/or liver get big enough, they can press against other organs like the stomach. This can make the child feel full after eating only a small amount of food, leading to a loss of appetite and weight loss over time.

Swollen lymph nodes: Some leukemias spread to lymph nodes. Swollen nodes may be seen or felt as lumps under the skin in certain areas of the body (such as on the

sides of the neck, in underarm areas, above the collarbone, or in the groin). Lymph nodes inside the chest or abdomen can also swell, but these can only be seen on [imaging tests](#), such as CT or MRI scans.

In infants and children, lymph nodes often get bigger when they are fighting an infection. An enlarged lymph node in a child is much more often a sign of infection than leukemia, but it should be checked by a doctor and followed closely.

Coughing or trouble breathing: Some types of leukemia can affect structures in the middle of the chest, such as lymph nodes or the thymus (a small organ in front of the trachea, the breathing tube that leads to the lungs). An enlarged thymus or lymph nodes in the chest can press on the trachea, causing coughing or trouble breathing. In some cases where the white blood cell count is very high, the leukemia cells can build up in the small blood vessels of the lungs, which can also cause trouble breathing.

Swelling of the face and arms: The superior vena cava (SVC), a large vein that carries blood from the head and arms back to the heart, passes next to the thymus. An enlarged thymus may press on the SVC, causing the blood to “back up” in the veins. This is known as *SVC syndrome*. It can cause swelling in the face, neck, arms, and upper chest (sometimes with a bluish-red skin color). It can also cause headaches, dizziness, and a change in consciousness if it affects the brain. The SVC syndrome can be life-threatening, and needs to be treated right away.

Headache, seizures, vomiting: A small number of children have leukemia that has already spread to the brain and spinal cord when they are first diagnosed. This can lead to symptoms such as headache, trouble concentrating, weakness, seizures, vomiting, problems with balance, and blurred vision.

Rashes, gum problems: In children with acute myelogenous leukemia (AML), leukemia cells may spread to the gums, causing swelling, pain, and bleeding. If it spreads to the skin, it can cause small, dark spots that look like common rashes. A collection of AML cells under the skin or in other parts of the body is called a *chloroma* or *granulocytic sarcoma*.

Extreme fatigue, weakness: A rare but very serious consequence of AML is extreme tiredness, weakness, and slurring of speech. This can occur when very high numbers of leukemia cells cause the blood to become too thick and slow the circulation through small blood vessels of the brain.

Again, most of the symptoms above are more likely to be caused by something other than leukemia. Still, it's important to have these symptoms checked by a doctor so the cause can be found and treated, if needed.

- [References](#)

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How Is Childhood Leukemia Diagnosed?

Most of the [signs and symptoms](#) of childhood leukemia are more likely to have other causes, such as infections. Still, it's important to let your child's doctor know about such symptoms right away so that the cause can be found and treated, if needed.

Exams and tests will be done to determine the cause of the symptoms. If leukemia is found, further tests will be needed to find out [what type](#) it is and decide how it should be treated.

It's important to diagnose childhood leukemia as early as possible and to determine what type of leukemia it is so that treatment can be tailored to provide the best chance of success.

Medical history and physical exam

If your child has signs and symptoms that might suggest leukemia, the doctor will want to get a thorough medical history to learn about the symptoms and how long your child has had them. The doctor may also ask about exposure to possible [risk factors](#). A family history of cancer, especially leukemia, may also be important.

During the physical exam, the doctor will focus on any enlarged lymph nodes, areas of bleeding or bruising, or possible signs of infection. The eyes, mouth, and skin will be looked at carefully, and a nervous system exam may be done. The abdomen (belly) will be felt for signs of an enlarged spleen or liver.

Tests to look for leukemia in children

If the doctor thinks your child might have leukemia, samples of your child's blood and bone marrow will need to be checked to be sure of the diagnosis. Your child's doctor may refer you to a *pediatric oncologist*, a doctor who specializes in childhood cancers (including leukemias), to have some of these tests done. If leukemia is found, other body tissue and cell samples may also be taken to help guide treatment.

Blood tests

The first tests done to look for leukemia are blood tests. The blood samples are usually taken from a vein in the arm, but in infants and younger children they may be taken from other veins (such as in the feet or scalp) or from a "finger stick."

Blood counts and blood smears are the usual tests done on these samples. A [complete blood count](#) (CBC) is done to determine how many blood cells of each type are in the blood. For a blood smear, a small sample of blood is spread on a glass slide and looked at under a microscope. Abnormal numbers of blood cells and changes in the way these cells look may make the doctor suspect leukemia.

Most children with leukemia will have too many white blood cells and not enough red blood cells and/or platelets. Many of the white blood cells in the blood will be *blasts*, an early type of blood cell normally found only in the bone marrow. Even though these findings may make a doctor suspect that a child has leukemia, usually the disease can't be diagnosed for sure without looking at a sample of bone marrow cells.

Bone marrow aspiration and biopsy

Bone marrow samples are obtained from a bone marrow aspiration and biopsy – 2 tests that are usually done at the same time. The samples are usually taken from the back of the pelvic (hip) bones, but sometimes they may be taken from the front of the pelvic bones or from other bones.

For a bone marrow *aspiration*, the skin over the hip bone is cleaned and numbed by injecting a local anesthetic or applying a numbing cream. In most cases, the child is also given other medicines to make them drowsy or even go to sleep during the procedure. A thin, hollow needle is then inserted into the bone, and a syringe is used to suck out (aspirate) a small amount of liquid bone marrow.

A bone marrow *biopsy* is usually done just after the aspiration. A small piece of bone and marrow is removed with a slightly larger needle that is pushed down into the bone. Once the biopsy is done, pressure will be applied to the site to help prevent any bleeding.

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

Lumbar puncture (spinal tap)

This test is used to look for leukemia cells in the cerebrospinal fluid (CSF), which is the liquid that bathes the brain and spinal cord.

For this test, the doctor first applies a numbing cream in an area in the lower part of the back over the spine. The doctor usually also gives the child medicine to make him or her sleep during the procedure. A small, hollow needle is then placed between the bones of the spine to withdraw some of the fluid.

It is very important for this test to be done by an expert. Doctors have found that if the spinal tap isn't performed expertly and some blood leaks into the CSF, in some cases leukemia cells may get into the fluid and grow there.

In children already diagnosed with leukemia, the first lumbar puncture is also used to give chemotherapy drugs into the CSF to try to prevent or treat the spread of leukemia to the spinal cord and brain.

Lymph node biopsy

This type of biopsy is important in diagnosing lymphomas, but it is rarely needed for children with leukemias.

During this procedure, a surgeon cuts through the skin to remove an entire lymph node (excisional biopsy). If the node is near the skin surface, this is a simple operation. But it is more involved if the node is inside the chest or abdomen. Most often the child will need general anesthesia (where the child is asleep).

Lab tests to diagnose and classify leukemia

Microscopic exams

As mentioned above, blood counts and smears are usually the first tests done when leukemia is a possible diagnosis. Any other samples taken (bone marrow, lymph node tissue, or CSF) are also looked at under a microscope. The samples might be exposed to chemical stains (dyes) that can cause color changes in some types of leukemia cells.

Doctors will look at the size, shape, and staining patterns of the blood cells in the samples to classify them into specific types. (See the section “ [How is childhood leukemia classified?](#)” for more information on the types of leukemia.)

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 *blasts*. Having too many blasts in the sample, especially in the blood, is a typical sign of leukemia.

An important feature of a bone marrow sample is its *cellularity*. Normal bone marrow contains a certain number of blood-forming cells and fat cells. Marrow with too many blood-forming cells is said to be *hypercellular*. If too few blood-forming cells are found, the marrow is called *hypocellular*.

Flow cytometry and immunohistochemistry

These tests are used for *immunophenotyping* – classifying leukemia cells based on certain proteins in or on the cells. This kind of testing is very helpful in determining the exact type of leukemia. It is most often done on cells from bone marrow, but it can also be done on cells from the blood, lymph nodes, and other body fluids.

For both flow cytometry and immunohistochemistry, samples of cells are treated with antibodies that stick to certain proteins. For immunohistochemistry, the cells are then examined under a microscope to see if the antibodies stuck to them (meaning they have these proteins), while for flow cytometry a special machine is used.

Flow cytometry can also be used to estimate the amount of DNA in the leukemia cells. This is important to know, especially in ALL, because cells with more DNA than normal (a *DNA index* of 1.16 or higher) are often more sensitive to chemotherapy, and these leukemias have a better prognosis (outlook).

Flow cytometry can also be used to measure the response to treatment and the existence of minimal residual disease (MRD, see “ [Prognostic factors in childhood leukemia](#)”) in some types of leukemias.

Chromosome tests

Normal human cells have 23 pairs of chromosomes (strands of DNA), each of which is a certain size and looks a certain way under the microscope. But in some types of leukemia, the cells have changes in their chromosomes.

For instance, sometimes 2 chromosomes swap some of their DNA, so that part of one chromosome becomes attached to part of a different chromosome. This change, called a *translocation*, can usually be seen under a microscope. Other types of chromosome changes are also possible. Recognizing these changes can help identify certain types of acute leukemias and can help determine prognosis (outlook).

Some types of leukemia have cells with an abnormal number of chromosomes (instead of the usual 46) – they may be missing some chromosomes or have extra copies of some. This can also affect a patient's outlook. For example, in ALL, chemotherapy is more likely to work if the cells have more than 50 chromosomes and is less likely to work if the cells have fewer than 46 chromosomes.

Finding these types of chromosome changes with lab tests can be very helpful in predicting a person's outlook and response to treatment.

Cytogenetics: For this test, leukemia cells are grown in a lab dish and the chromosomes are looked at under a microscope to detect any changes, including missing or extra chromosomes. (Counting the number of chromosomes by cytogenetics provides similar information to measuring the DNA index by flow cytometry, as described above.)

Cytogenetic testing 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.

Not all chromosome changes can be seen under a microscope. Other lab tests can often help detect these changes.

Fluorescent in situ hybridization (FISH): This is another way to look at chromosomes and genes. It uses pieces of DNA that only attach to specific parts of particular chromosomes. The DNA is linked to fluorescent dyes that can be seen with a special microscope. FISH can find most 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 specific changes in chromosomes. It can be used on blood or bone marrow samples. It is very accurate and can usually provide results within a couple of days.

Polymerase chain reaction (PCR): This is a very sensitive test that can also find some chromosome changes too small to be seen under a microscope, even if there are very few leukemia cells in a sample. This test can be very useful in looking for small numbers

of leukemia cells (minimal residual disease, or MRD) during and after treatment that might not be detected with other tests.

Other blood tests

Children with leukemia will have tests to measure certain chemicals in the blood to check how well their body systems are working.

These tests aren't used to diagnose leukemia, but in children already known to have it, they can help find damage to the liver, kidneys, or other organs caused by the spread of leukemia cells or by certain chemotherapy drugs. Tests are also often done to measure blood levels of important minerals, as well as to make sure the blood is clotting properly.

Children might also be tested for blood infections. It's important to diagnose and treat infections in children with leukemia quickly because their weakened immune systems can allow infections to spread.

Imaging tests

Imaging tests use x-rays, sound waves, magnetic fields, or radioactive particles to make pictures of the inside of the body. Leukemia doesn't usually form tumors, so imaging tests aren't as useful as they are for other types of cancer. But if leukemia is suspected or has been diagnosed, your child's doctor may order some of these tests to get a better idea of the extent of the disease or to look for other problems, such as infections. (For more details on imaging tests, see [Imaging \(Radiology\) Tests](#).)

Chest x-rays

A chest x-ray can help detect an enlarged thymus or lymph nodes in the chest. If the test result is abnormal, a computed tomography (CT) scan of the chest may be done to get a more detailed view.

Chest x-rays can also help look for pneumonia if your child might have a lung infection.

Computed tomography (CT) scan

The CT scan uses x-rays to make detailed, cross-sectional images of the body. Unlike a regular x-ray, CT scans can show the detail in soft tissues such as internal organs.

This test isn't usually needed to diagnose leukemia, but it might be done if the doctor suspects the leukemia is growing in lymph nodes in the chest or in organs like the spleen or liver. It is also sometimes used to look at the brain and spinal cord, but an MRI scan may also be used for this.

Before the scan, your child 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. He or she may need an IV line through which the contrast dye is injected.

The IV injection of contrast dye can cause a feeling of flushing or warmth in the face or elsewhere. Some people are allergic and get hives or, rarely, have more serious reactions like trouble breathing and low blood pressure. Be sure to tell the doctor if your child has any allergies (especially to iodine or shellfish) or has ever had a reaction to any contrast material used for x-rays.

CT scans take longer than regular x-rays. A CT scanner has been described as a large donut, with a narrow table that slides in and out of the middle opening. Your child will need to lie still on the table while the scan is being done. Some children might need to be sedated before the test to help make sure they stay still so the pictures come out well.

PET/CT scan: Some machines combine the CT scan with a positron emission tomography (PET) scan. For a PET scan, a form of radioactive sugar (known as *fluorodeoxyglucose* or FDG) is injected into the blood. (The amount of radioactivity used is very low and will pass out of the body within a day or so.) Because cancer cells grow rapidly, they absorb large amounts of the sugar. A special camera can then create a picture of areas of radioactivity in the body. The picture from the PET scan is not detailed like those from a CT scan, but it provides helpful information about the whole body. The PET/CT scan lets the doctor compare areas of higher radioactivity on the PET scan with the more detailed appearance of that area on the CT scan.

Magnetic resonance imaging (MRI) scan

An MRI scan, like a CT scan, makes detailed images of soft tissues in the body. It's most helpful in looking at the brain and spinal cord, so it's most likely to be done if the doctor has reason to think the leukemia might have spread there (such as if the child has symptoms like headaches, seizures, or vomiting).

MRI scans use radio waves and strong magnets instead of x-rays, so there is no radiation involved.

A contrast material called *gadolinium* is often injected into a vein before the scan to better show details. This contrast material usually does not cause allergic reactions.

MRI scans take longer than CT scans – often up to an hour. Your child may have to lie inside a narrow tube, which is confining and can be distressing, so sedation is sometimes needed. Newer, more open MRI machines may be another option, although they still require that your child be able to lie still. All MRI machines make loud buzzing and clicking noises that your child may find disturbing. Some places provide headphones or earplugs to help block this out.

Ultrasound

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

This test can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside the abdomen such as the kidneys, liver, and spleen. (It can't be used to look at organs or lymph nodes in the chest because the ribs block the sound waves.)

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

This is a fairly easy test to have, and it uses no radiation. Your child simply lies on a table, and a technician moves the transducer over the part of the body being looked at.

Bone scan

This test is not done often for childhood leukemias, but it may be useful if your child has bone pain that might be from either an infection or cancer in the bones. If your child has already been diagnosed with leukemia or if a PET scan (described above) has already been done, there is usually no need for a bone scan.

For this test, the doctor or nurse injects a small amount of a slightly radioactive chemical into the bloodstream. (The amount of radioactivity used is very low and will pass out of the body within a day or so.) The substance settles in areas of damaged bone throughout the skeleton over the course of a couple of hours. Your child then lies on a table for about 30 minutes while a special camera detects the radioactivity and creates a picture of the skeleton. Younger children may be given medicine to help keep them

calm or even asleep during the test.

Areas of bone changes appear as hot spots on the skeleton because they attract the radioactivity, but the image isn't very detailed. If an area lights up on the scan, other imaging tests such as x-rays or CT or MRI scans may be done to get a more detailed look at the area. If leukemia is a possibility, a biopsy of the area may be needed to confirm this.

- [References](#)

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How Is Childhood Leukemia Classified?

The type of leukemia a child has plays a major role in both treatment options and the child's outlook (prognosis). Determining the type (acute lymphocytic, acute myeloid, etc.) and subtype of the leukemia is done by testing samples of the blood, bone marrow, and sometimes lymph nodes or cerebrospinal fluid (CSF), as described in "[How is childhood leukemia diagnosed?](#)"

For most types of cancer, determining the stage (extent) of the cancer is very important. The stage is based on the size of the tumor and how far the cancer has spread. But leukemia is not staged like most other cancers. It starts in the bone marrow and quickly spreads to the blood, so leukemia cells are already scattered throughout the body.

Still, it's important to know whether the leukemia cells have started to collect in other organs such as the liver, spleen, lymph nodes, testicles, or central nervous system (brain and spinal cord). For instance, if the leukemia cells have spread to the central nervous system in large numbers, they will be seen in samples of CSF. Treatment must be more intense to kill these leukemia cells. This is why a spinal tap (lumbar puncture) is done as part of the early diagnostic testing.

Acute lymphocytic (lymphoblastic) leukemia (ALL)

Acute lymphocytic leukemia (ALL) is a fast-growing cancer of lymphocyte-forming cells called *lymphoblasts*.

Classification based on how the leukemia cells look (morphology)

In the past, doctors used the French-American-British (FAB) classification to divide ALL into 3 major groups (L1, L2, or L3) based on how the cells looked under the microscope. Some doctors may still refer to these categories. But newer lab tests now let doctors classify ALL based on more than just how the cells look under the microscope.

Classification based on immunophenotype

Newer types of [lab tests](#) can help determine the subtype of ALL and the patient's prognosis. These tests help divide ALL into groups based on the *immunophenotype* of the leukemia, which takes into account:

- The type of lymphocyte (B cell or T cell) the leukemia cells come from
- How mature these leukemia cells are

B-cell ALL: In about 80% to 85% of children with ALL, the leukemia starts in B cells. There are several subtypes of B-cell ALL:

- **Early precursor B (early pre-B) ALL** (also called *pro-B ALL*)
- **Common ALL**
- **Pre-B ALL**
- **Mature B-cell ALL** (also called *Burkitt leukemia*). This type is rare, accounting for only about 2% to 3% of childhood ALL. It is essentially the same as Burkitt lymphoma and is treated differently from most leukemias. It's discussed in detail in [Non-Hodgkin Lymphoma in Children](#).

T-cell ALL: About 15% to 20% of children with ALL have T-cell ALL. This type of leukemia affects boys more than girls and generally affects older children more than does B-cell ALL. It often causes an enlarged thymus (a small organ in front of the windpipe), which can sometimes cause breathing problems. It may also spread to the cerebrospinal fluid (the fluid that surrounds the brain and spinal cord) early in the course of the disease.

Aside from the subtype of ALL, other factors are important in determining outlook (prognosis). These are described in the section “[Prognostic factors in childhood leukemia](#).”

Acute myelogenous leukemia (AML)

Acute myelogenous leukemia (AML) is typically a fast-growing cancer of one of the following types of early (immature) bone marrow cells:

- **Myeloblasts:** These cells normally form white blood cells called *granulocytes* (neutrophils, eosinophils, and basophils).
- **Monoblasts:** These cells normally become white blood cells called *monocytes* and *macrophages*.
- **Erythroblasts:** These cells mature into red blood cells.
- **Megakaryoblasts:** These cells normally become megakaryocytes, the cells that make platelets.

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

French-American-British (FAB) classification of AML

The older FAB system divides AML into subtypes based on the type of cell the leukemia started in and how mature the cells are. In this system, the subtypes of AML are classified mainly based on their morphology (how they look under the microscope). There are 8 subtypes of AML: M0 to M7 (the M refers to myeloid).

- **M0:** Undifferentiated acute myeloblastic leukemia
- **M1:** Acute myeloblastic leukemia with minimal maturation
- **M2:** Acute myeloblastic leukemia with maturation (the most common subtype of AML in children)
- **M3:** Acute promyelocytic leukemia (APL)
- **M4:** Acute myelomonocytic leukemia (more common in children less than 2 years of age)
- **M5:** Acute monocytic leukemia (more common in children less than 2 years of age)
- **M6:** Acute erythroid leukemia
- **M7:** Acute megakaryoblastic leukemia

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

World Health Organization (WHO) classification of AML

The FAB classification system is still commonly used to group AML into subtypes. But it doesn't take into account many other factors that are now known to affect prognosis (outlook), such as chromosome changes in the leukemia cells. The newer WHO system includes some of these factors to help better classify AML based on a person's outlook.

The WHO system divides AML into several groups:

AML with certain genetic abnormalities

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

AML with myelodysplasia-related changes

AML related to previous chemotherapy or radiation

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

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

Myeloid sarcoma (also known as granulocytic sarcoma or chloroma)

Myeloid proliferations related to Down syndrome

Undifferentiated and biphenotypic acute leukemias (leukemias that have both lymphocytic and myeloid features). These are also known as *mixed phenotype* or *mixed lineage* leukemias. In children, these leukemias are generally treated like ALL and usually respond to treatment like ALL.

Chronic myelogenous leukemia (CML)

Chronic myelogenous leukemia (CML) is typically a slower-growing cancer of early (immature) myeloid bone marrow cells. CML is not common in children, but it can occur.

The course of CML is divided into 3 phases, based mainly on the number of immature white blood cells – myeloblasts (“blasts”) – that are seen in the blood or bone marrow. Different groups of experts have suggested slightly different cutoffs to define the phases, but a common system (proposed by the World Health Organization) is described below.

If the leukemia is not cured with treatment, it can progress to more advanced phases over time.

Chronic phase

This is the earliest phase, in which patients typically have less than 10% blasts in their blood or bone marrow samples. These children usually have fairly mild symptoms (if any), and the leukemia usually responds well to standard [treatments](#). Most patients are in the chronic phase when they are diagnosed.

Accelerated phase

Patients are considered to be in accelerated phase if bone marrow or blood samples have more than 10% but fewer than 20% blasts, or if levels of certain other blood cells are too high or too low.

Children whose CML is in accelerated phase may have symptoms such as fever, night sweats, poor appetite, and weight loss. CML in the accelerated phase might not respond as well to treatment as CML in the chronic phase.

Blast phase (also called acute phase or blast crisis)

In this phase, bone marrow and/or blood samples have more than 20% blasts. The blast cells often spread to tissues and organs beyond the bone marrow. These children often have fever, poor appetite, and weight loss. At this point the CML acts much like an aggressive acute leukemia (AML or, less often, ALL).

Not all doctors agree with or follow these cutoff points for the different phases. If you have questions about what phase your child’s CML is in, be sure to have the doctor

explain it to you.

- [References](#)

[See all references for Leukemia in Children](#)

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Prognostic Factors in Childhood Leukemia (ALL or AML)

Certain factors that can affect a child's outlook (prognosis) are called *prognostic factors*. They help doctors decide whether a child with leukemia should receive standard treatment or more intensive treatment. Prognostic factors seem to be more important in acute lymphocytic leukemia(ALL) than in acute myelogenous leukemia (AML).

Prognostic factors for children with ALL

Children with ALL are often divided into risk groups (such as standard-risk, high-risk, or very high-risk), with more intensive treatment given to higher risk patients. Generally, children at low risk have a better outlook than those at very high risk.

While all of the following are prognostic factors, only certain ones are used to determine which risk group a child falls into. (The first 2 factors – age at diagnosis and initial white blood cell count – are thought to be the most important.) It's important to know that even children with some poor prognostic factors can often still be cured.

Age at diagnosis: Children between the ages of 1 and 9 with B-cell ALL tend to have better cure rates. Children younger than 1 year and children 10 years or older are considered high-risk patients. The outlook in T-cell ALL isn't affected much by age.

Initial white blood cell (WBC) count: Children with ALL who have very high WBC counts (greater than 50,000 cells per cubic millimeter) when they are diagnosed are classified as high risk and need more intensive treatment.

Subtype of ALL: Children with pre-B, common, or early pre-B-cell ALL generally do better than those with mature B-cell (Burkitt) leukemia. The outlook for T-cell ALL seems to be about the same as that for B-cell ALL as long as treatment is intense enough.

Gender: Girls with ALL may have a slightly higher chance of being cured than boys. As treatments have improved in recent years, this difference has shrunk.

Race/ethnicity: African-American and Hispanic children with ALL tend to have a lower cure rate than children of other races.

Spread to certain organs: Spread of the leukemia into the cerebrospinal fluid (the fluid around the brain and spinal cord), or to the testicles in boys, lowers the chance of being cured. Enlargement of the spleen and liver is usually linked to a high WBC count, but some doctors view this as a separate sign that the outlook is not as favorable.

Number of chromosomes: Patients are more likely to be cured if their leukemia cells have more than 50 chromosomes (called *hyperdiploidy*), especially if there is an extra chromosome 4, 10, or 17. Hyperdiploidy can also be expressed as a [DNA index](#) of more than 1.16. Children whose leukemia cells have fewer chromosomes than the normal 46 (known as *hypodiploidy*) have a less favorable outlook.

Chromosome translocations: Translocations occur when chromosomes swap some of their genetic material (DNA). Children whose leukemia cells have a translocation between chromosomes 12 and 21 are more likely to be cured. Those with a translocation between chromosomes 9 and 22 (the Philadelphia chromosome), 1 and 19, or 4 and 11 tend to have a less favorable prognosis. Some of these “poor” prognostic factors have become less important in recent years as treatment has improved.

Response to treatment: Children whose leukemia responds completely (major reduction of cancer cells in the bone marrow) within 1 to 2 weeks of chemotherapy have a better outlook than those whose leukemia does not. Children whose cancer does not respond as well may be given more intensive chemotherapy.

Prognostic factors for children with AML

Prognostic factors are not quite as important in predicting outcome or in guiding treatment for AML as they are for ALL.

Age at diagnosis: Children younger than age 2 with AML seem to do better than older

children (especially teens), although age is not thought to have a strong effect on outlook.

Initial white blood cell (WBC) count: Children with AML whose WBC count is less than 100,000 cells per cubic millimeter at diagnosis are cured more often than those with higher counts.

Down syndrome: Children with Down syndrome who develop AML tend to have a good outlook, especially if the child is 4 years old or younger at the time of diagnosis.

Subtype of AML: Some subtypes of AML tend to have a better outlook than others. For example, the acute promyelocytic leukemia (APL) M3 subtype tends to have a good outlook, while undifferentiated AML (M0) and acute megakaryoblastic leukemia (M7) are harder to treat.

Chromosome changes: Children with leukemia cell translocations between chromosomes 15 and 17 (seen in most cases of APL) or between 8 and 21, or with an inversion (rearrangement) of chromosome 16 have a better chance of being cured. Children whose leukemia cells are missing a copy of chromosome 7 (known as *monosomy 7*) have a poorer prognosis.

Myelodysplastic syndrome or secondary AML: Children who first have myelodysplastic syndrome (“smoldering leukemia”) or whose leukemia is the result of treatment for another cancer tend to have a less favorable prognosis.

Response to treatment: Children whose leukemia responds quickly to treatment (only one chemotherapy cycle needed to achieve remission) are more likely to be cured than those whose leukemia takes longer to respond or does not respond at all.

Body weight: Children within the normal weight range tend to do better than children who are underweight or overweight.

Race/ethnicity: African-American and Hispanic children with ALL tend to have a lower cure rate than children of other races.

Status of acute leukemia after treatment

How well ALL or AML responds to the initial (induction) treatment affects long-term prognosis.

Remission

A remission (or *complete remission*) is usually defined as having no evidence of leukemia after the 4 to 6 weeks of induction 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 lab tests, such as [polymerase chain reaction \(PCR\)](#). Even when leukemia is in remission, this does not always mean that it has been cured.

Minimal residual disease

Minimal residual disease (MRD) is a term used after treatment when leukemia cells can't be found in the bone marrow using standard lab tests (such as looking at cells under a microscope), but they can still be detected with more sensitive tests (such as flow cytometry or PCR). In general, children with MRD during or after induction chemotherapy are more likely to have the leukemia relapse (come back) and therefore may need more intense treatment. Children with more MRD have a greater risk of relapse than those with less MRD.

Active disease

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

- [References](#)

[See all references for Leukemia in Children](#)

Last Medical Review: April 17, 2015 Last Revised: February 3, 2016

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Survival Rates for Childhood Leukemias

Survival rates are often used by doctors as a standard way of discussing a person's prognosis (outlook). Some parents may want to know the survival statistics for children in similar situations, while others may not find the numbers helpful, or may even not want to know them. If you would rather not read about the survival rates, skip to the section "[How is childhood leukemia treated?](#)"

When discussing cancer survival statistics, doctors often use a number called the *5-year survival rate*. This refers to the percentage of patients who live *at least* 5 years after their cancer is diagnosed. With acute leukemias, children who are free of the disease after 5 years are very likely to have been cured, because it's very rare for these cancers to return after this long.

Survival rates are often based on previous outcomes of large numbers of children who had the disease, but they can't predict what will happen in any child's case. Knowing the type of leukemia is important in estimating a child's outlook. But a number of other factors, including the child's age and leukemia characteristics, can also affect outlook. Many of these factors are discussed in the section "[Prognostic factors in childhood leukemia](#) (ALL or AML)." Even when taking these other factors into account, survival rates are at best rough estimates. Your child's doctor is likely to be a good source as to whether these numbers apply to your child, as he or she knows your situation best.

Current 5-year survival rates are based on children first diagnosed and treated more than 5 years ago. Improvements in treatment since then might result in a better outlook for children now being diagnosed.

Acute lymphocytic leukemia (ALL)

The 5-year survival rate for children with ALL has greatly increased over time and is now more than 85% overall.

Acute myelogenous leukemia (AML)

The overall 5-year survival rate for children with AML has also increased over time, and is now in the range of 60% to 70%. However, survival rates vary depending on the subtype of AML and other factors. For example, most studies suggest that the cure rate for acute promyelocytic leukemia (APL), a subtype of AML, is now higher than 80%, but rates are lower for some other subtypes of AML.

Other childhood leukemias

Accurate survival rates for less common forms of childhood leukemia are harder to find.

Juvenile myelomonocytic leukemia (JMML): For JMML, 5-year survival rates of about 50% have been reported.

Chronic leukemias: For chronic leukemias, which are rare in children, 5-year survival rates are less helpful, because some children may live for a long time with the leukemia without actually being cured. In the past, 5-year survival rates for chronic myelogenous leukemia (CML) were reported to be in the range of 60% to 80%. With newer, more effective medicines developed for CML in recent years, survival rates are likely to be higher now, although these new drugs have not been in use long enough to be sure.

- [References](#)

[See all references for Leukemia in Children](#)

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What Should You Ask Your Child's Doctor About Childhood Leukemia?

It's important to have open, honest discussions with your child's cancer care team. They want to answer all of your questions, no matter how small they might seem. For instance, consider these questions:

- What [kind of leukemia](#) does my child have?
- Are there any specific [factors that might affect my child's prognosis](#)?
- Do we need other [tests](#) before we can decide on treatment?
- Are there other doctors we need to see?
- How much experience do you have treating this type of leukemia?
- Should we get a second opinion? Can you recommend someone?
- What are our [treatment choices](#)?
- Should we consider a [stem cell transplant](#)? When?
- What do you recommend and why?

- How soon do we need to start treatment?
- What should we do to be ready for treatment?
- How long will treatment last? What will it be like?
- How much of the treatment will need to be done in the hospital?
- How will treatment affect our daily lives (school, work, etc.)?
- What are the risks and side effects of the treatments you recommend?
- Which side effects start shortly after treatment and which ones might develop later on?
- Will treatment affect my child's ability to learn, grow, and develop?
- Will treatment affect my child's future ability to have children?
- What are the chances of curing the leukemia?
- What will our options be if the treatment doesn't work or if the leukemia comes back?
- What type of [follow-up](#) will we need after treatment?
- Can we talk to support groups or other families who have been through this?

Along with these sample questions, be sure to write down your own. For instance, you might want to ask if your child qualifies for any [clinical trials](#). You may also want to ask about the typical costs of treatment, and what is likely to be covered by insurance.

Also keep in mind that doctors are not the only ones who can give you information. Other health care professionals, such as nurses and social workers, may have the answers to some of your questions. You can find out more about speaking with your health care team in [Talking With Your Doctor](#).

- [References](#)

[See all references for Leukemia in Children](#)

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