Acute Myelogenous Leukemia
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**WHAT IS LEUKEMIA?**

*Leukemia* is a cancer of the blood and bone marrow system. In general, there are two classifications of leukemia: acute leukemia (rapidly progressing) and chronic leukemia (slowly progressing). There are also two types of leukemia: lymphoid (arising from the lymphoid cell line) and myeloid (arising from the myeloid cell line). The lymphoid cell line produces *lymphocytes*, a type of white blood cell (WBC). WBCs are the cells that make up the body’s immune system. The immune system is the body’s primary defense against infection. The myeloid cell line produces other types of WBCs, red blood cells (RBCs), and platelets.

**WHAT IS BONE MARROW?**

*Bone marrow* is the spongy tissue located in the center of bones, which is where the blood cells are developed. This process of blood cell development is called *hematopoiesis*. The process of hematopoiesis starts with a stem cell and results in the formation of RBCs, WBCs, and platelets. When these cells are fully developed, they enter the blood system and circulate throughout the body.

**BONE MARROW CELLS**

<table>
<thead>
<tr>
<th>Red Blood Cells</th>
<th>Carry oxygen throughout the body</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Blood Cells</td>
<td>Help the body fight infection</td>
</tr>
<tr>
<td>Platelets</td>
<td>Prevent bleeding and promote clotting</td>
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</tbody>
</table>

**WHAT IS ACUTE MYELOGENOUS LEUKEMIA?**

*Acute myelogenous leukemia* (AML) is a rapidly progressing type of leukemia that develops from the myeloid cell line. AML occurs from the overproduction of very young, immature cells called *leukemia blasts*. These blasts (immature blood cells) cannot carry out the normal function of a healthy blood cell. Instead, they crowd within the bone marrow and decrease the production of normal bone marrow cells.

**AML SUBTYPES**

There are different subtypes of AML. The subtype will be determined when the results of the bone marrow aspirate are complete. Knowing the specific type of AML that your child has is important because it will help to determine the type of therapy that will be used. The chart on the next page outlines the subtypes of AML.
M0  Leukemia originates from very immature WBCs.
M1  Leukemia originates from young myeloblasts, a type of WBC.
M2  Leukemia originates from mature myeloblasts, a type of WBC.
M3  Leukemia originates from promyelocytes, a type of WBC.
M4  Leukemia originates from myelocytes and monocytes, types of WBCs.
M5  Leukemia originates from monocytes, a type of WBC.
M6  Leukemia originates from erythrocytes, a type of RBC.
M7  Leukemia originates from megakaryocytes, a platelet cell.

WHAT ARE THE SIGNS AND SYMPTOMS OF AML?

Signs and symptoms of AML vary in severity from patient to patient. They typically result from the overcrowding of the bone marrow by the abnormal leukemia cells. There is little room in the bone marrow for the normal cells (RBCs, WBCs, and platelets) to develop. As a result, your child is at risk for anemia, infection, and bleeding. In addition, the leukemia cells circulate in the blood stream and settle into other parts of the body, causing infiltration (congestion) or swelling in these areas.

Some of the common signs and symptoms of AML include

- fatigue (become tired easily)
- paleness
- easy bruising or bleeding
- fevers
- recent infections
- bone pain
- swollen gums
- weight loss or anorexia (loss of appetite)
- swollen lymph nodes
- swollen liver or spleen.

WHAT CAUSES AML?

We do not know what causes AML, but we do know that some things may increase the risk of developing AML. These include previous exposure to certain chemotherapy agents (alkylating agents or topoisomerase inhibitors) and radiation therapy. Certain genetic disorders are also associated with an increased risk for developing AML, including Down’s syndrome, Fanconi’s anemia, myelodysplastic syndrome, monosomy 7 and Shwachman-Diamond syndrome, neurofibromatosis type 1, Bloom syndrome, and Kostmann granulocytopenia. Tobacco smoke exposure has also been noted to increase the risk of getting AML. AML is not contagious and cannot be passed from one person to another.
WHO DEVELOPS AML?

There are approximately 3,500 new cases of leukemia diagnosed in children each year in the United States. Of these children, approximately 15%–20%, or about 1 in 5 children, will be diagnosed with AML. This is roughly 720 cases of AML in children each year.

WHERE IS AML FOUND IN THE BODY?

AML begins in the bone marrow and travels into the peripheral blood (circulating bloodstream). It also can be found in the cerebral spinal fluid (the fluid that surrounds the brain) in some children. AML may develop under the surface of the skin and appear as raised lesions on the skin (or subcutaneous nodules). In rare instances, the leukemia cells will clump together and form a mass or tumor. These tumors are referred to as chloromas.

WHAT TESTS AND PROCEDURES WILL MY CHILD NEED?

Blood Tests

Blood tests are done to monitor your child’s blood cells and body chemistries. The complete blood count (CBC) is used to detect anemia (low hemoglobin or hematocrit, a measure of low RBCs), detect changes in WBCs (infection-fighting cells), and detect changes in platelets (cells that help the blood clot). The percentage of leukemia blasts or immature WBCs are also assessed. A chemistry panel will look at your child’s electrolytes (salt and sugar levels) and liver and kidney function.

Bone Marrow Aspiration and Biopsy

Bone marrow aspiration and biopsy are the primary tests used in the diagnosis of leukemia. These tests determine whether leukemia cells are present in the bone marrow (the blood-producing factory in the body). Bone marrow aspiration involves inserting a special needle into one of the bones (usually the front or back part of the hip bone) and drawing some bone marrow into a syringe. It sometimes is necessary to obtain bone marrow from both the right and left hip bones. Another part of this test involves taking a small piece of the bone to examine for leukemia cells. This is referred to as a bone marrow biopsy. Bone marrow aspirate and biopsy are the only ways to positively determine whether leukemia cells are in the bone marrow. This test helps the physician determine the type of leukemia that your child has and to choose proper treatment. Sedation medication or sometimes general anesthesia can be used to help your child remain still and to prevent or minimize discomfort during the procedure. Your child may experience some mild discomfort after the procedure, which is usually relieved with a mild pain reliever such as acetaminophen. However, it is best to discuss the use of any medication with your child’s physician or healthcare provider prior to use.
Cytogenetic Analysis

Cytogenetic analysis is the process of analyzing alterations in chromosomes of cells, during which abnormalities in the number and structure of these chromosomes are carefully assessed. It is important to note that chromosomal abnormalities found in the cytogenetic analysis of a child with leukemia refer only to abnormalities of the chromosomes of the leukemia cells, not to other cells in the body. Abnormalities in the chromosomal number and structure of leukemia cells do not imply that your child has a genetic problem. Cytogenetic analysis of these leukemia cells is important in determining the best treatment for your child's leukemia.

Lumbar Puncture

The central nervous system (brain, spinal cord, and cerebral spinal fluid) is a hiding place for leukemia cells. To determine whether leukemia has spread into the central nervous system, your child must undergo a lumbar puncture, also referred to as a spinal tap. In a lumbar puncture, a small needle is inserted into the back between the lower spinal bones (vertebrae) to obtain a sample of cerebral spinal fluid (CSF). The fluid is sent to the laboratory and examined for any evidence of leukemia. Some children require sedation to remain still during this procedure. The results of the lumbar puncture will help the physicians determine the type of treatment your child will receive.

Venous Access Device

A venous access device (VAD), sometimes called a central line, is an intravenous (IV) catheter that may be used for the duration of your child’s therapy. It is inserted during surgery when your child is under heavy sedation or general anesthesia. It can be used to administer medication, chemotherapy (cancer-fighting drugs), blood products, and nutritional support. It also may be used to draw blood for testing purposes. The VAD may remain in your child for the duration of treatment and will be removed surgically when it is no longer needed.

HOW IS AML TREATED?

Treatment for AML is determined according to the risk assignment for your child’s disease. Risk assignment is based on the type of AML your child has, any risk factors identified during his or her initial bone marrow evaluation (cytogenetic results), and his or her response to the first round of chemotherapy. Some children may have the opportunity to take part in a clinical trial that is testing newer drugs to treat AML.

Chemotherapy

All children with AML are treated with chemotherapy. The chemotherapy drugs used to treat AML are typically administered intravenously (through the VAD). Depending on the drug used, it may be given rapidly or over a prolonged period of time for many days. Children with AML are hospitalized to receive their medications and frequently remain hospitalized for several weeks. The chemotherapy used to treat AML is very strong and lowers blood counts significantly. When blood counts are low, your child is at risk for infections, bleeding, and other complications. The safest way to treat and possibly prevent serious infections is to have your child remain in the hospital where he or she can be closely monitored and quickly given antibiotics if needed.
Intrathecal Chemotherapy

All children with AML are treated with intrathecal chemotherapy, which is chemotherapy given directly into the spinal fluid by performing a lumbar puncture (spinal tap) and slowly injecting the drug into the spinal fluid. Even if no leukemia cells are detected in the spinal fluid, intrathecal chemotherapy is given at the start of each cycle of chemotherapy to prevent the leukemia cells from spreading to the spinal fluid. For children with AML cells in their spinal fluid at diagnosis, intrathecal chemotherapy is given more frequently to treat the leukemia. Some children require sedation to remain still during lumbar punctures.

Side Effects of Chemotherapy

In addition to killing AML cells, cancer chemotherapy can damage normal tissue and cause side effects. Side effects from chemotherapy often begin soon after chemotherapy is initiated and continue for 2–4 weeks. Common side effects include nausea, vomiting, hair loss, fatigue, and diarrhea. The most common serious side effect from chemotherapy is a drop in normal blood counts. Many chemotherapy drugs used to treat AML can cause anemia (low RBC count), thrombocytopenia (low platelet count), and neutropenia (low WBC count). AML therapy often causes neutropenia, which places a child at risk for developing life-threatening infections and can last for several weeks. Children may need to remain in the hospital after chemotherapy until their blood counts recover to decrease the risk of severe infection. Some side effects may last longer than a few weeks or may not occur until years after therapy. Your child's healthcare team will continue to see your child after his or her treatment has been completed. Certain tests may be performed to look for any late effects of treatment.

Monoclonal Antibody Therapy

Monoclonal antibodies are a new class of drugs for the treatment of AML. They have shown promising results in adult studies as well as in preliminary children's studies. These antibodies are used to deliver drugs and toxins to cancer cells. For patients with AML, the antibody attaches to a protein found on the surface of many AML cells. This class of drugs is sometimes referred to as “magic bullets.” These drugs target and deliver most of the chemotherapy to the leukemia cells and therefore spare the normal healthy cells from the effects of treatment. Currently, these drugs are used in combination with chemotherapy to improve the long-term survival of children with AML.

Side Effects of Monoclonal Antibody Therapy

Common side effects for monoclonal antibody therapy include nausea, vomiting, headache, loss of appetite, fever and chills (most common with first dose), fatigue, and weakness. As with chemotherapy, the most serious common side effect is lowering of the blood counts. When chemotherapy and monoclonal antibodies are used together, the side effects may be more severe. Veno-occlusive disease (VOD) of the liver is a possible side effect of AML when receiving monoclonal antibody therapy. VOD causes an increase in bilirubin in the blood, jaundice (temporary yellowing of the skin), an enlarged and painful liver, and retention of fluid (resulting in weight gain). Less common side effects include rash, hives, irregular heart beat during infusion, dizziness or fainting, anxiety, and difficulty sleeping. A rare but serious side effect is an allergic reaction during the infusion.
Bone Marrow Transplant

Bone marrow transplant may be considered as a treatment option for children with AML who have a sibling with the same human leukocyte antigen (HLA) tissue typing or for children who have high-risk AML (high-risk AML is defined as AML that did not achieve remission after induction chemotherapy or AML that has relapsed). HLA type refers to the unique set of proteins called human leukocyte antigens. These proteins are present on the surface of the WBCs. HLA typing is a test to determine how closely the tissue of one person matches the tissue of another person. The tissue typing is obtained either through a blood test or by swabbing the inside of the mouth. HLA typing is done on the child with AML, his or her parents, and any full siblings soon after diagnosis. There is a 25% chance that two full siblings will share the same HLA type. All patients who undergo bone marrow transplantation will first receive intensive chemotherapy to achieve remission.

WHAT IS A CLINICAL TRIAL?

Most of the advances in the treatment of childhood cancer have been made through the use of clinical trials. During clinical trials, the best-known, standard treatment for a particular cancer is compared with a new experimental treatment. The experimental treatment is believed to be at least as good as, and possibly better than, the standard treatment. Clinical trials allow doctors to determine whether promising new treatments are safe and effective.

Participation in clinical trials is voluntary. Because clinical trials involve research into new treatment plans, all risks cannot be known ahead of time, and unknown side effects may occur. However, children who participate in clinical trials can be among the first to benefit from new treatment approaches. Before making a decision about your child’s participation in a clinical trial, you should discuss the risks as well as the potential benefits with your child’s doctor and treatment team.

WHAT DOES REMISSION MEAN?

Remission is defined as less than 5% leukemia cells remaining in the bone marrow in the presence of recovering blood counts. The bone marrow aspirate test usually is repeated at the end of the first induction course of chemotherapy. Some patients with AML may show signs of improvement after the first cycle of chemotherapy but still have more than 5% of the leukemia cells in the bone marrow. Some children require two or more courses of induction chemotherapy to achieve remission. A child who is not in remission at the end of induction therapy has high-risk AML.

WHAT IS REFRACTORY AML?

Refractory AML occurs when a child fails to achieve remission after completion of induction chemotherapy. Children with refractory AML require a more aggressive chemotherapy treatment to achieve remission.
WHAT IS RELAPSE?
Relapse occurs when the AML cells return in the bone marrow after remission has been achieved. If your child’s AML relapses, your healthcare team will meet with you to discuss further treatment options.

HOW LONG DO THERAPIES LAST?
Treatment for AML generally lasts 6–8 months. If your child undergoes a bone marrow transplant, recovery time may be longer than if he or she were treated only with chemotherapy.

WHAT IS MY CHILD’S PROGNOSIS?
About 50% of children diagnosed with AML are cured, which means they have not had any signs of cancer for 5 years after completing therapy. Cure rates for children with refractory or relapsed AML are much lower.

WHAT ARE NEW METHODS OF TREATMENT?
Researchers are looking for better ways to treat AML. New drugs to treat AML are being researched, including monoclonal antibodies, new chemotherapy drugs, and a class of drugs called “inhibitors.” Bone marrow transplants using a donor who is not related to the child with leukemia also are being studied as a treatment for children who have high-risk AML.

WHAT ARE THE POTENTIAL LATE EFFECTS?
AML therapy may result in chronic side effects that can occur years after completing treatment. Possible side effects may include damage to the heart muscle and development of new cancer caused by the chemotherapy (secondary malignancy). Another possible side effect from treatment is infertility or sterility (unable to conceive or father a child).
 HOW CAN I WORK WITH MY CHILD’S HEALTHCARE TEAM?

Your child’s care requires a team approach. As a parent, you know your child better than anybody else and therefore are an important member of the team caring for your child. It is important that you talk openly with your child’s healthcare team. Be sure to ask questions of your child’s doctor or nurse if there is anything that you do not understand or are concerned about. You may find it helpful to write down your questions when you think of them. Here are some examples of questions to ask:

• What kind of cancer does my child have?
• Has the cancer spread beyond the primary site?
• What is the stage of the cancer, and what does that mean?
• What treatment choices are available?
• What treatment do you recommend and why?
• What risks or side effects does the recommended treatment have?
• What should we do to prepare for treatment?
• What is my child’s outlook for survival?
• What are the chances of a recurrence?

Use this space to write down some additional questions.
ARE MY FEELINGS NORMAL, AND WHAT CAN I DO ABOUT THEM?

Hearing that your child has cancer can be shocking and overwhelming. At first you may not believe it, or you may hope that the diagnosis is wrong. However, the changes you see in your child and the experience of being in the hospital and beginning treatment will confirm the reality of your child’s situation.

Many family members feel they are responsible for their child’s disease, or they feel guilty that they were not able to detect it sooner. Remember that this disease often does not become noticeable until it is quite advanced, so there may have been no way to detect it in the early stages.

In addition to shock and guilt, you and your family will probably feel angry and sad. Even the youngest family members are likely to be affected. These feelings are normal, and each family member will express them in different ways and at different times. It can be very difficult to feel so many strong emotions at once. Talking honestly with one another about feelings, reactions, and questions will help everyone in the family.

It may seem difficult to talk to friends, family, or even medical staff, but expressing your feelings can help you cope with this situation. Remember that your child will benefit if family members continue to show their caring through support and communication.

HOW CAN I HELP MY CHILD?

As a parent, you will likely notice changes in your child during the treatment. These changes or symptoms can make you feel even more helpless. It is essential to remember that, in spite of changes on the outside, your child is still the same person on the inside. Hair loss and other changes in the body are temporary. They often bother adults much more than they bother the child or the child’s siblings and friends. All of the feelings about what your child is going through during treatment must be balanced by remembering that treatment provides an opportunity to cure the disease so your child can go on to live a full and meaningful life.

It is important to reinforce to your child that nothing he or she did or said caused this disease. Telling your child that your angry or sad feelings are directed at cancer and not at him or her will preserve honesty and closeness in your relationship.

Like you, your child will need someone with whom he or she can share feelings. Don’t hesitate to ask your child to express his or her feelings, and don’t be afraid to explain what is happening and why.

In spite of the disease, your child is still growing and learning. All children—sick and well—need love, attention, discipline, limits, and the opportunity to learn new skills and try new activities. As you begin to learn about the new special needs of your child, it is important to remember that he or she still has all the needs and rights of any growing, developing child.
When talking to your child about his or her illness, do not avoid using direct terms and explanations. Children tolerate treatment better if they understand it and are allowed to be an active decision maker whenever possible. The same is true for parents.

### IS MY CHILD’S DIET IMPORTANT DURING THE TREATMENT?

Yes. We know from research that well-nourished children tolerate therapy better and have fewer treatment delays due to illness. It may be difficult for your child to resume normal eating habits during therapy, so you will need to be flexible and creative. Offering smaller meals more often may be more successful than offering larger meals three times a day. Children usually are more interested in eating food that they help prepare. It is important to include your child in the social activity of family meals even if full meals are not eaten. Remember, nobody wins food fights—it’s best not to force your child to eat.

Make sure that foods high in protein and carbohydrates are readily available to your child. It may be necessary throughout your child’s treatment to provide supplemental nutritional support. Multivitamins, medicines, and herbs should be discussed with your healthcare team before you give them to your child, because an interaction between them and the chemotherapy is possible. A dietician trained in children’s calorie and energy needs can offer you guidance. The medical staff can help if there is a nutritional problem.

### CAN MY CHILD ATTEND SCHOOL DURING TREATMENT?

Your child’s ability to attend school will depend on the intensity of the therapy and on the response to treatment. Some children tolerate chemotherapy and radiation better than others. Your child may not be able to attend school for extended periods because of treatment or hospitalization. However, it is important that your child keep up with his or her schoolwork. Talk to the staff at your child’s school about arranging additional services, such as help from a home tutor, until he or she is able to return to school. You should also discuss school attendance with your child’s doctor. Many pediatric hospitals have programs that allow children to attend school while they are hospitalized.

School is important because it helps children maintain social contact with their peers. Your child’s time with friends will be an important part of recovery and will ease the adjustment when he or she returns to school. It is important for your child to return to school as soon as he or she is medically able to do so.
BIBLIOGRAPHY


IMPORTANT PHONE NUMBERS

NOTES