LEUKEMIA--ACUTE LYMPHOCYTIC

What is cancer?

Cancer develops when cells in a part of the body begin to grow out of control. Although there are many kinds of cancer, they all start because of out-of-control growth of abnormal cells.

Normal body cells grow, divide, and die in an orderly fashion. During the early years of a person's life, normal cells divide more rapidly until the person becomes an adult. After that, cells in most parts of the body divide only to replace worn-out or dying cells and to repair injuries.

Because cancer cells continue to grow and divide, they are different from normal cells. Instead of dying, they outlive normal cells and continue to form new abnormal cells.

Cancer cells develop because of damage to DNA. This substance is in every cell and directs all its activities. Most of the time when DNA becomes damaged the body is able to repair it. In cancer cells, the damaged DNA is not repaired. People can inherit damaged DNA, which accounts for inherited cancers. Many times though, a person’s DNA becomes damaged by exposure to something in the environment, like smoking.

Cancer usually forms as a tumor. Some cancers, like leukemia, do not form tumors. Instead, these cancer cells involve the blood and blood-forming organs and circulate through other tissues where they grow.

Often, cancer cells travel to other parts of the body, where they begin to grow and replace normal tissue. This process is called metastasis. Regardless of where a cancer may spread, however, it is always named for the place it began. For instance, breast cancer that spreads to the liver is still called breast cancer, not liver cancer.

Not all tumors are cancerous. Benign (non-cancerous) tumors do not spread (metastasize) to other parts of the body and, with very rare exceptions, are not life threatening.

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

Cancer is the second leading cause of death in the United States. Nearly half of all men and a little over one third of all women in the United States will develop cancer during their lifetimes. Today, millions of people are living with cancer or have had cancer. The risk of developing most types of cancer can be reduced by changes in a person's lifestyle, for example, by quitting smoking and eating a better diet. The sooner a cancer is found and treatment begins, the better are the chances for living for many years.

What Is Acute Lymphocytic Leukemia?

Acute lymphocytic leukemia (ALL), also called acute lymphoblastic leukemia, is a cancer that starts from white blood cells called lymphocytes in the bone marrow (the soft inner part of the bones, where new blood cells are made). In most cases, the leukemia invades the blood fairly quickly. It can then spread to other parts of the body including the lymph nodes, liver, spleen, central nervous system (brain and spinal cord), and testes. Other types of cancer that start in these organs and then spread to the bone marrow are not leukemia.

The other types of cancer that start in lymphocytes are known as lymphomas (non-Hodgkin lymphoma or Hodgkin disease). The main difference between these types of cancers is that ALL starts in the bone marrow and may spread to other places, while lymphomas start in lymph nodes or other organs and then may spread to the bone marrow. Sometimes cancerous lymphocytes are found in both the bone marrow and lymph nodes when the cancer is first diagnosed , which can make it hard to tell if the cancer is a leukemia or a lymphoma.. If more than 25% of the bone marrow is replaced by cancerous lymphocytes, the disease is usually considered to be a leukemia. The size of lymph nodes is also important. The bigger they are, the more likely the disease is a lymphoma. For more information on lymphoma, see our document, *Non-Hodgkin Lymphoma*.

The term "acute" means that the leukemia can progress quickly, and if not treated, would probably be fatal in a few months. "Lymphocytic" or "lymphoblastic" means it develops from cells called lymphocytes or lymphoblasts. This is different from acute myeloid leukemia (AML), which develops in another white blood cell type found in the bone marrow. For more information on this type of leukemia, see the ACS document, *Leukemia--Acute Myeloid*.

Normal Bone Marrow, Blood, and Lymphoid Tissue

In order to understand the different types of leukemia, it is helpful to have some basic knowledge about the blood and lymph systems.

Bone Marrow

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

The blood-forming cells come from blood *stem cells*. These stem cells only make new blood-forming cells and not other kinds of cells. (This makes them different from embryonic stem cells, which are formed in a developing fetus and can grow into most other cell types in the body.)

Stem cells go through a series of changes. During this process, the cells develop into either *lymphocytes* (a kind of white blood cell) or other blood-forming cells. The blood-forming cells can develop into 1 of the 3 main types of blood cell components: red blood cells, white blood cells (other than lymphocytes), or platelets.

Red Blood Cells

Red blood cells carry oxygen from the lungs to all other tissues in the body, and take carbon dioxide back to the lungs to be removed. Anemia (having too few red blood cells in the body) typically causes weakness, fatigue, and shortness of breath because the body tissues are not getting enough oxygen.

Platelets

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

White Blood Cells

White blood cells are important in defending the body against infections. Lymphocytes are one type of white blood cell. The other types of white blood cells are granulocytes (neutrophils, basophils, and eosinophils) and monocytes.

Lymphocytes: 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 gland, the spleen, the tonsils and adenoids, and is scattered throughout the digestive and respiratory systems and the bone marrow.

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

- **B lymphocytes:** B lymphocytes protect the body from invading germs by developing (maturing) into plasma cells, which make antibodies. These antibodies attach to the germs, such as bacteria, viruses, and fungi. Once the germ has been coated in this way, other white blood cells called granulocytes can recognize and destroy it.

- **T lymphocytes** T lymphocytes can recognize cells infected by viruses and directly destroy these cells.

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

Monocytes: Monocytes which are related to granulocytes, also are important in protecting the body against bacteria. They start in the bone marrow as blood-forming *monoblasts* and develop into mature monocytes. After circulating in the bloodstream for about a day, monocytes enter body tissues to become *macrophages*, which can destroy some germs by surrounding and digesting them. Macrophages are also important in helping lymphocytes recognize germs and start making antibodies to fight them.

Any blood-forming or lymphoid cell from the bone marrow can turn into a leukemia cell. Once this change takes place, the leukemia cells fail to go through their normal process of maturing. Although leukemia cells may reproduce quickly, in most cases they don't die when they should. They survive and accumulate. Over time, these cells spill into the bloodstream and spread to other organs, where they can keep other cells in the body from functioning normally.

Types of Leukemia

Not all leukemias are the same. Leukemias are divided into 4 main types. Knowing the specific type of leukemia can help doctors better predict each patient's prognosis (outlook) and select the best treatment.

Acute leukemia versus chronic leukemia

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

Acute leukemia: In *acute* leukemia, the bone marrow cells cannot mature properly. Immature leukemia cells continue to reproduce and build up. Without treatment, most patients with acute leukemia would live only a few months. Some types of acute leukemia respond well to treatment, and many patients can be cured. Other types of acute leukemia have a less favorable outlook.

Chronic leukemia: In *chronic* leukemia, the cells can mature partly but not completely. These cells are not really normal. They generally do not fight infection as well as do normal white blood cells. And, of course, they survive longer, build up, and crowd out normal cells. Chronic leukemias tend to progress over a longer period of time, and most patients can live for many years. However, chronic leukemias are generally harder to cure than acute leukemias.

Myeloid leukemia versus lymphocytic leukemia

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

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

Lymphocytic leukemia: If the cancer starts in early forms of lymphocytes, it is called *lymphocytic* leukemia (also known as *lymphoid* leukemia). Lymphomas are also cancers of lymphocytes. But, unlike lymphocytic leukemias, which develop in the bone marrow, lymphomas develop from lymphocytes in lymph nodes or other organs.

By considering whether they are acute or chronic, and whether they are myeloid or lymphocytic, leukemias 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)

Although ALL is the most common of the 4 major types of leukemia among children, it is actually the least common type among adults.

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

What Are the Key Statistics About Acute Lymphocytic Leukemia?

About 44,270 new cases of leukemia will be diagnosed in the United States during 2008. Of these, about 5,430 will be acute lymphocytic leukemia (ALL). Although this is a leukemia that occurs mostly in children, about 1 out of 3 ALL cases occurs in an adult.

About 1,460 people will die of acute lymphocytic leukemia in the United States during 2008. About 3 out of 4 these deaths will be in adults.

The risk for ALL is highest in children between 2 and 4 years of age. The risk then declines slowly until the mid-20s, and begins to rise again slowly after age 50.

The average person's lifetime risk of getting ALL is about 1/10 of 1% (about 1 in 1,000). The risk is slightly higher in men than in women, and higher in whites than in African Americans.

Some information on treatment success rates for adult ALL can be found in the section, How Is Acute Lymphocytic Leukemia Treated?

What Are the Risk Factors for Acute Lymphocytic Leukemia?

A risk factor is something that affects a person's chance of getting a disease such as cancer. For example, exposing skin to strong sunlight is a risk factor for skin cancer. Smoking is a risk factor for a number of cancers.

But having a risk factor, or even several risk factors, does not mean that you definitely will get the disease. And many people who get the disease may not have had any known risk factors.

There are only a few known risk factors for acute lymphocytic leukemia (ALL).

Radiation exposure

Exposure to high levels of radiation is a risk factor for acute leukemia (both ALL and acute myeloid leukemia, or AML). Japanese atomic bomb survivors had a greatly increased risk of developing acute leukemia, usually within 6 to 8 years after exposure. Similar risks have occurred after exposure to radiation from nuclear reactor accidents.

The possible risks of leukemia from exposure to lower levels of radiation, such as from radiation therapy, x-rays, or CT scans, is not well-defined. Exposure of a fetus to radiation within the first months of development may also carry an increased risk of leukemia, although the extent of the risk is not clear. If there is an increased risk it is likely to be small, but to be safe, most doctors try to limit a person's exposure to radiation as much as possible.

Chemical exposure

The risk of ALL may be increased by exposure to certain chemicals, including benzene and certain chemotherapy drugs. Chemical exposure is more strongly linked to an increased risk of AML.

Certain viral infections

Infection with the human T-cell lymphoma/leukemia virus-1 (HTLV-1) can cause a rare type of T-cell acute lymphocytic leukemia. Most cases occur in Japan and the Caribbean area. This disease is not common in the United States.

Epstein-Barr virus (EBV) causes infectious mononucleosis ("mono"). In Africa, the virus has been linked to Burkitt lymphoma, as well as to a form of acute lymphocytic leukemia.

Inherited syndromes

Acute lymphocytic leukemia does not appear to be an inherited disease. It does not seem to run in families, so a person's risk is not increased if a family member has the disease. But there are some inherited syndromes that include genetic changes that seem to raise the risk of ALL. These include:

- Down syndrome
- Klinefelter syndrome
- Fanconi anemia
- Bloom syndrome
- Ataxia-telangiectasia
- neurofibromatosis

Race/ethnicity

ALL is more common in whites than in African Americans, although the reasons for this are not clear.

Gender

ALL is slightly more common in males than in females. The reason for this is unknown.

Having an identical twin with acute lymphocytic leukemia

This risk is largely confined to the first year of life. As mentioned earlier, most cases of ALL are not thought to have a strong genetic link. Many doctors feel the increased risk among identical twins may be due to leukemia cells being passed from one fetus to the other while still in the womb.

Uncertain, unproven or controversial risk factors

Other factors that have been studied for a possible link to ALL include:

- exposure to electromagnetic fields (such as living near power lines)
- workplace exposure to diesel, gasoline, and certain other chemicals and solvents
- smoking
- exposure to hair dyes

So far, none of these factors has been linked conclusively to ALL. Research in these areas continues

Do We Know What Causes Acute Lymphocytic Leukemia?

Although some people with acute lymphocytic leukemia (ALL) have one or more of the known risk factors mentioned earlier, most do not. The cause of their cancer remains unknown at this time. Even when a patient has one or more risk factors, there is no way to tell whether it actually caused the cancer. And many people with one or more cancer risk factors never develop this disease.

Normal human cells grow and function based mainly on the information contained in each cell's chromosomes. Chromosomes are long molecules of DNA in each cell. DNA is the chemical that makes up our genes - the instructions for how our cells function. We resemble our parents because they are the source of our DNA. But our genes affect more than the way we look.

Some genes contain instructions for controlling when our cells grow and divide. Certain genes that promote cell division are called *oncogenes*. Others that slow down cell division or cause cells to die at the right time are called *tumor suppressor genes.*

Each time a cell prepares to divide into 2 new cells, it must make a new copy of the DNA in its chromosomes. This process is not perfect, and errors can occur that may affect genes within the DNA. Cancers can be caused by DNA mutations (changes) that turn on oncogenes or turn off tumor suppressor genes.

Translocations are the best known type of DNA abnormality that can lead to leukemia. Human DNA is packaged in 23 pairs of chromosomes. A translocation means that DNA from one chromosome breaks off and becomes attached to a different chromosome. The point at which the break occurs can affect genes - for example, it can cause oncogenes to be turned on.

The most common translocation in ALL is known as the Philadelphia chromosome, which is a swapping of DNA (translocation) between chromosomes 9 and 22, abbreviated as t(9;22).

It occurs in about 3% to 5% of childhood ALL cases and 20% to 30% of adult ALL cases. Other, less common translocations are those between chromosomes 4 and 11, abbreviated as t(4;11), or 8 and 14, abbreviated as t(8;14).

Other chromosome changes such as *deletions* (the loss of part of a chromosome) and *inversions* (the rearrangement of the DNA in part of a chromosome) can also affect the development of ALL, although they are much rarer. In many cases of ALL, the gene changes that lead to the leukemia are not known.

Some people with certain types of cancer have inherited DNA mutations from a parent. These changes increase their risk for the disease. But ALL is very rarely caused by one of these inherited mutations.

Usually DNA mutations related to ALL occur during the person's lifetime rather than having been inherited before birth. They may result from exposure to radiation or cancer-causing chemicals, but they often occur for no apparent reason.

Can Acute Lymphocytic Leukemia Be Prevented?

Although many types of cancer can be prevented by lifestyle changes to avoid certain risk factors, there is no known way to prevent most cases of leukemia at this time. Since most acute lymphocytic leukemia patients have no known risk factors, there is no way to prevent these leukemias from developing.

Can Acute Lymphocytic Leukemia Be Found Early?

For many types of cancers, diagnosis at the earliest possible stage makes treatment much more effective. The American Cancer Society recommends screening tests for early diagnosis of certain cancers in people without any symptoms.

But at this time there are no special tests recommended to detect acute lymphocytic leukemia early. The best way to find leukemia early is to report any possible signs or symptoms of leukemia (described in the next section) to the doctor right away.

People with a known increased risk of leukemia because of an inherited disorder such as Down syndrome should have thorough, regular medical checkups. The development of leukemia in people with these syndromes, although greater than in the general population, is still very rare.

How Is Acute Lymphocytic Leukemia Diagnosed?

Signs and Symptoms of Acute Lymphocytic Leukemia

Acute lymphocytic leukemia (ALL) can cause many different signs and symptoms. Most of these occur in all kinds of ALL, but some are more common with certain subtypes.

Generalized Symptoms

Patients with ALL often have several non-specific symptoms. These can include weight loss, fever, and loss of appetite. Of course, these are not just symptoms of ALL and are more often caused by something other than cancer.

Shortage of Blood Cells

Most signs and symptoms of ALL result from a shortage of normal blood cells, which happens when the leukemia cells crowd out the normal blood-making cells in the bone marrow. As a result, people do not have enough normal red blood cells, white blood cells, and blood platelets. These shortages show up on blood tests, but they can also cause symptoms.

- *Anemia* is a shortage of red blood cells. It can cause tiredness, weakness, feeling dizzy, cold, or lightheaded, and shortness of breath.

- A shortage of normal white blood cells (leukopenia) increases the risk of infections. A common term you may hear is *neutropenia*, which refers specifically to low levels of neutrophils (a type of granulocyte). Although patients with ALL may have high white blood cell counts due to excess numbers of lymphocytes (*lymphocytosis*), the leukemia cells do not protect against infection the way normal white blood cells do. Fevers and recurring infections are some of the most common symptoms of ALL.

- A shortage of blood platelets (*thrombocytopenia*) can lead to excess bruising, bleeding, frequent or severe nosebleeds, and bleeding gums.

Bone or Joint Pain

Some patients have bone pain or joint pain caused by the buildup of leukemia cells near the surface of the bone or inside the joint.

Swelling in the Abdomen

Leukemia cells may collect in the liver and spleen, causing them to enlarge. This may be noticed as a fullness or swelling of the belly. The lower ribs usually cover these organs, but when they are enlarged the doctor can feel them.

Enlarged Lymph Nodes

Acute lymphocytic leukemia may spread to lymph nodes. If the affected nodes are close to the surface of the body (on the sides of the neck, in the groin, in underarm areas, above the collarbone, etc.), they may be noticed as lumps under the skin. Lymph nodes inside the chest or abdomen may also swell, but these can be detected only by imaging tests such as computed tomography (CT) or magnetic resonance imaging (MRI) scans.

Spread to Other Organs

Less often, ALL may spread to other organs. If it spreads to the brain and spinal cord (central nervous system, or CNS) it can cause headaches, weakness, seizures, vomiting, trouble with balance, facial numbness, and blurred vision. ALL may also spread to the chest cavity, where it can cause fluid buildup and trouble breathing. On rare occasions it may spread to the skin, eyes, testicles, kidneys, or other organs.

Enlarged Thymus Gland

The T-cell subtype of ALL often affects the thymus, which is a small gland in the middle of the chest located behind the sternum (breastbone) and in front of the trachea (windpipe). An enlarged thymus can press on the trachea, causing coughing, shortness of breath, or even suffocation.

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. Growth of the thymus due to excess leukemia cells 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 and arms and a bluish-red coloration of the head, arms, and upper chest. It can also cause trouble breathing and a change in consciousness if it affects the brain. The SVC syndrome can be life-threatening, and requires immediate attention.

Medical History and Physical Exam

Most of the symptoms seen in leukemia can also be seen in other problems like infections. For this reason, an accurate diagnosis is crucial.

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

The physical exam will probably focus on looking for 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 thorough nervous system exam will be done. The abdomen will be felt for signs of an enlarged spleen or liver.

If there is reason to think the problems might be caused by abnormal numbers of blood cells (anemia, infections, bleeding or bruising, etc.), the doctor will likely test the patient's blood counts. If the results suggest leukemia may be the cause, the doctor may refer the patient to a cancer doctor, who may run one or more of the tests described below.

Types of Specimens Used to Test for Acute Lymphocytic Leukemia

If signs and symptoms suggest that a patient may have leukemia, the doctor will need to check samples of cells from the patient's blood and bone marrow to be sure of the diagnosis. Other tissue and cell samples may also be taken to help guide treatment.

Blood Samples

Blood samples for tests for ALL are generally taken from a vein in the arm.

Bone Marrow Samples

Bone marrow samples are obtained from a bone marrow aspiration and biopsy - two tests that are usually done at the same time. The samples are usually taken from the back of the pelvic (hip) bone, although in some cases they may be taken from the sternum (breastbone) or other bones.

In bone marrow *aspiration*, you lie on a table (either on your side or on your belly). After the area is cleaned, the skin over the hip and the surface of the bone are numbed with local anesthetic, which may cause a brief stinging or burning sensation. A thin, hollow needle is then inserted into the bone and a syringe is used to suck out a small amount of liquid bone marrow (about 1 teaspoon). Even with the anesthetic, most patients still have some brief discomfort when the marrow is removed.

A bone marrow *biopsy* is usually done just after the aspiration. A small piece of bone and marrow (about 1/16 inch in diameter and 1/2 inch long) is removed with a slightly larger needle that is twisted as it is pushed down into the bone. The biopsy may also briefly cause some pain. Once the biopsy is done, pressure will be applied to the site to help prevent bleeding.

These bone marrow tests are used to help diagnose leukemia. They may also be done again later to tell if the leukemia is responding to therapy.

Lumbar Puncture (Spinal Tap)

This important test looks for leukemia cells in the cerebrospinal fluid (CSF), which is the liquid that surrounds the brain and spinal cord. A lumbar puncture can also be used to put chemotherapy drugs into the CSF to prevent or treat the spread of leukemia to the spinal cord and brain.

For this test, the patient may be lying on their side or sitting up. The doctor first numbs an area in the lower part of the back near the spine. A small needle is then placed between the bones of the spine to withdraw some of the fluid.

Excisional Lymph Node Biopsy

In this procedure, a surgeon cuts through the skin to remove an entire lymph node. If the node is near the skin surface, this is a simple operation that can be done with local anesthesia, but if the node is inside the chest or abdomen, general anesthesia (where the patient is asleep) is used. This is an important procedure when diagnosing lymphomas, but is only rarely needed with leukemias.

Lab Tests Used to Diagnose and Classify Acute Lymphocytic Leukemia

One or more of the following lab tests may be used to diagnose ALL, to determine what subtype of ALL it is, and/or to help determine how advanced the disease is.

Blood Cell Counts and Blood Cell Examination

These tests look at the numbers of the different types of blood cells and at how they look under the microscope. Changes in the numbers and the appearance of these cells help in diagnosing leukemia. Most patients with ALL have too many immature white cells in their blood, and not enough red blood cells or platelets. Many of the white blood cells will be lymphoblasts (blasts), an immature type of lymphocyte not normally found in the bloodstream. These immature cells do not function like normal, mature white blood cells. Even though these findings suggest leukemia, the disease usually is not diagnosed without looking at a sample of bone marrow cells.

Blood Chemistry and Coagulation Tests

These tests measure the amounts of certain chemicals in the blood, but they are not used to diagnose leukemia. In patients already known to have ALL, these tests can help detect liver or kidney problems caused by spreading leukemic cells or the side effects of certain chemotherapy drugs. These tests also help determine if treatment is needed to correct low or high blood levels of certain minerals. Blood tests may also be done to make sure the blood is clotting properly.

Routine Microscopic Exam

Any samples taken (blood, bone marrow, lymph node tissue, or CSF) are looked at under a microscope by a pathologist (a doctor specializing in diagnosing diseases with lab tests) and may be reviewed by the patient's hematologist/oncologist (a doctor specializing in cancer and blood diseases).

Based on the cells' size, shape, and staining patterns, doctors can classify them into specific cell types. A key element of this classification is whether the cells appear mature (look like normal cells of circulating blood), or immature (do not have features of normal blood cells). The most immature cells are called *blasts*.

Determining what percentage of cells in the bone marrow are blasts is particularly important. A diagnosis of acute lymphocytic leukemia generally requires that at least 20% to 30% of the bone marrow are blasts. For a patient to be considered in remission after treatment, the blast percentage must be no higher than 5%.

Sometimes just counting and looking at the cells does not provide a definite answer, and other lab tests are needed.

Cytochemistry

Cytochemistry tests expose cells to chemical stains (dyes) that react with only some types of leukemia cells. These stains cause color changes that can be seen under a microscope, which can help the doctor determine what types of cells are present. For instance, one stain can help distinguish acute lymphocytic leukemia (ALL) cells from other types of acute myeloid leukemia (AML) cells. The stain causes the granules of most AML cells to appear as black spots under the microscope, but it does not cause ALL cells to change colors.

Flow Cytometry

This technique is often used to look at the cells from bone marrow, lymph nodes, and blood samples. It is very accurate in determining the exact type of leukemia.

The test looks for certain substances on the surface of cells that help identify what types of cells they are. A sample of cells is treated with special antibodies (man-made immune system proteins) that stick to the cells only if these certain substances are present on their surfaces. The cells are then passed in front of a laser beam. If the cells now have antibodies attached to them, the laser will cause them to give off light, which can be measured and analyzed by a computer. Groups of cells can be separated and counted by these methods.

Related tests, called immunohistochemistry tests, can be used to detect these substances when viewing cells under a microscope.

These tests are used for *immunophenotyping* -- classifying leukemia cells according to the substances (antigens) on their surfaces. Different types of lymphocytes have different antigens on their surface. These antigens may also change as each cell matures. Every leukemia cell should have the same antigen because they are all derived from the same cell. Lab testing for antigens is a very sensitive way to diagnose ALL. Because different subtypes of ALL cells have different sets of antigens, this is sometimes helpful in ALL classification, although it is not needed in most cases.

Cytogenetics

This test looks at chromosomes (long strands of DNA) under a microscope to detect any changes. Normal human cells contain 23 pairs of chromosomes, each of which is a certain size and stains a certain way. In some cases of leukemia, the cells have chromosome changes that can be seen under a microscope.

For instance, 2 chromosomes may swap some of their DNA, so that part of one chromosome becomes attached to part of a different chromosome. This change, called a *translocation*, can usually be seen under a microscope. Recognizing these changes can help identify certain types of ALL and may be important in determining the outlook for the patient.

Most of the chromosome changes in ALL are translocations. The most common one is a translocation between chromosomes 9 and 22, which results in a shortened chromosome 22 (the Philadelphia chromosome). About 20%-30% of adults with ALL have this abnormality in their leukemia cells. These leukemias are often very hard to treat.

Information about this and other translocations may be useful in predicting response to treatment. For this reason, most doctors will test all patients with ALL for genetic changes in the leukemia cells.

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 viewed under the microscope.

Fluorescent In Situ Hybridization

Fluorescent in situ hybridization (FISH) is similar to cytogenetic testing. It can find most translocations that are visible under a microscope in standard cytogenetic tests, as well as some translocations too small to be seen with usual cytogenetic testing. It uses special fluorescent dyes that only attach to specific parts of particular chromosomes. FISH can be used to look for specific changes in chromosomes. It can be used on regular blood or bone marrow samples. It is very accurate and can usually provide results within a couple of days, which is why this test is now used in many medical centers.

Very sensitive DNA tests such as **polymerase chain reaction (PCR)** can also find translocations too small to be seen under a microscope, even if there are very few leukemia cells present in a sample.

These tests may also be used after treatment to detect small numbers of leukemia cells that may not be visible under a microscope.

Imaging Tests

Imaging tests produce pictures of the inside of the body. Because leukemia does not usually form visible tumors, imaging tests are of limited value. Several imaging tests might be done in people with ALL, but they are done more often to look for infections or other problems, rather than for the leukemia itself. In some cases they may be done to help determine the extent of the disease, if it is thought it may have spread beyond the bone marrow and blood.

X-rays

Routine chest x-rays may be done if the doctor suspects a lung infection is present. These also may be done to look for enlarged lymph nodes in the chest.

Computed Tomography Scan

The computed tomography (CT) scan is a type of x-ray test that produces detailed, cross-sectional images of your body. Unlike a regular x-ray, CT scans can show the detail in soft tissues (such as internal organs). This test can help tell if any lymph nodes or organs in your body are enlarged. It isn't usually needed to diagnose ALL, but it may be done if your doctor suspects leukemia cells are growing in an organ, like your spleen.

Instead of taking one picture, as does a regular x-ray, a CT scanner takes many pictures as it rotates around you. A computer then combines these pictures into detailed images of the part of your body that is being studied.

Often after the first set of pictures is taken, you will receive an intravenous (IV) injection of a contrast dye, or you may also be asked to drink a solution of contrast material, to better outline blood vessels and internal organs. A second set of pictures is then taken.

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, more serious reactions like trouble breathing and low blood pressure. Be sure to tell the doctor if you have ever had a reaction to any contrast material used for x-rays.

CT scans take longer than regular x-rays. You need to lie still on a table while they are being done. During the test, the table moves in and out of the scanner, a ring-shaped machine that completely surrounds the table. You might feel a bit confined by the ring you have to lay in when the pictures are being taken.

In some cases, a CT can be used to guide a biopsy needle precisely into a suspected abnormality, such as an abscess. For this procedure, called a *CT-guided needle biopsy*, you stay on the CT scanning table while a radiologist moves a biopsy needle through the skin and toward the location of the mass. CT scans are repeated until the needle is within the mass. A fine needle biopsy sample (tiny fragment of tissue) or a core needle biopsy sample (a thin cylinder of tissue about ½-inch long and less than 1/8-inch in diameter) is then removed to be looked at under a microscope.

Magnetic Resonance Imaging Scan

Magnetic resonance imaging (MRI) scans use radio waves and strong magnets instead of x-rays. The energy from the radio waves is absorbed by the body and then released in a pattern formed by the type of body tissue and by certain diseases. A computer translates the pattern into a very detailed image of parts of the body. Not only does this create images of cross-sectional slices of the body like a CT scanner, it can also produce images of slices that are parallel with the length of your body. A contrast material might be injected, just as with CT scans, but is used less often.

MRI scans are very helpful in looking at the brain and spinal cord.

MRI scans take longer than CT scans -- often up to an hour. You may have to lie inside a narrow tube, which is confining and can upset people with a fear of enclosed spaces. Newer, more open MRI machines can help with this if needed. The MRI machine makes loud buzzing noises that you may find disturbing. Some places provide headphones to block this out.

Ultrasound

Ultrasound uses sound waves and their echoes to produce a picture of internal organs or masses. For this test, a small, microphone-like instrument called a transducer is placed on the skin (which is first lubricated with oil). The transducer emits sound waves and picks up the echoes as they bounce off the organs. The echoes are converted by a computer into an image that is displayed on a computer screen.

Ultrasound can be used to look for enlarged organs inside your abdomen such as the kidneys, liver, and spleen.

This is an easy test to have done, and it uses no radiation. You simply lie on a table, and a technician moves the transducer over the part of your body being looked at.

Gallium Scan and Bone Scan

One of these tests may be useful if a patient has bone pain that might be due to either bone infection or cancer in the bones. If you have already been diagnosed with leukemia, there is usually no need for these studies.

For these tests, the radiologist injects a slightly radioactive chemical into the bloodstream, which collects in areas of cancer or infection in the body. These areas can then be viewed with a special type of camera. The images from these scans are seen as "hot spots" in the body, but they don't provide much detail. If an area lights up on the scan, x-rays, CTs, or MRIs of the affected area can be done to get a more detailed look. If leukemia is a possibility, a biopsy of the area may be needed to confirm this.

How Is Acute Lymphocytic Leukemia Classified?

Most types of cancers are assigned numbered stages based on the size of the tumor and how far from the original site in the body the cancer has spread.

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

The French-American-British (FAB) Classification

Several years ago, an international conference of doctors specializing in leukemia was held to decide on the best system to classify acute lymphocytic leukemia (ALL). This group of French, American, and British (FAB) doctors divided ALL into 3 subtypes. The FAB system was based only on the way the leukemia cells looked under the microscope after routine staining.

French-American-British (FAB) Classification of ALL

FAB Subtype	Approximate % of Adult ALL Patients	Immunologic Type	Comments
L1	30%	T cell or pre-B cell	
L2	65%	T cell or pre-B cell	
L3	5%	B cell	Poor prognosis with standard therapy. Also called Burkitt leukemia.

Classification Based on Immunophenotype

More recently, doctors have found that cytogenetic studies, flow cytometry, and molecular genetic studies provide more detailed information about 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) and the level of maturity of the leukemia cells. These groups have largely replaced the FAB classification. The subtypes of ALL are now named as follows:

B-cell ALL

- early pre-B ALL (also called pro-B ALL) - about 10% of cases
- common ALL - about 50% of cases

- pre-B ALL - about 10% of cases
- mature B-cell ALL (Burkitt leukemia) - about 4% of cases

T-cell ALL

- pre-T ALL - about 5% to 10% of cases
- mature T-cell ALL - about 15% to 20% of cases

Although the subtypes of ALL carry slightly different outlooks, other factors (like gene changes in the leukemia cells) may also have an impact. Some of these prognostic factors are listed in the next section.

Mixed Lineage Acute Leukemias

In recent years, newer tests have shown that a small number of ALL cases actually have both lymphocytic and myeloid features. Sometimes the leukemia cells have both myeloid and lymphocytic traits on the same cell. In other cases, a leukemia patient may have some cells with myeloid features and others with lymphocytic features. These types of leukemias may be called mixed lineage leukemia, ALL with myeloid markers (My+ ALL), AML with lymphoid markers, or biphenotypic acute leukemia (BAL).

Most studies suggest these leukemias have a poorer outlook than standard subtypes of ALL or AML. There is no standard treatment for these leukemias. Intensive treatment (such as stem cell transplant) is often used when possible, as they have a high risk of recurrence after treatment.

Prognostic Factors

As leukemia treatment has improved over the years, research has focused on why some patients have a better chance for cure than others. Differences among patients that affect response to treatment are called *prognostic factors.* They help doctors decide if people with a certain type of leukemia should receive more or less treatment. These prognostic factors include the patient's age, white blood cell count, ALL subtype, cytogenetic test results, and response to chemotherapy.

Adult Acute Lymphocytic Leukemia Prognostic Factors

- **Age:** Younger patients tend to have a better prognosis than older patients. There is no set cutoff for this, but generally those younger than 50 do better than those in their 50s, while people in their 50s do better than those in their 60s or older.

- **Initial white blood cell count:** People with a lower WBC count (less than 50,000) at the time of diagnosis tend to have a better prognosis.
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- **ALL subtype:** In general, T-cell ALL has a better prognosis, while mature B-cell ALL (Burkitt leukemia) has a poorer prognosis. Other subtypes of B-cell ALL fall somewhere in between. It's important to note that these rules aren't absolute. For instance, some subtypes of T-cell ALL have a better outlook than others.

- **Chromosome translocations:** The presence of Philadelphia chromosome (a translocation between chromosomes 9 and 22), which is found in 20% to 25% of ALL cases, predicts a poorer prognosis. The same is true of a translocation between chromosomes 4 and 11, which is found in about 5% of cases.

- **Response to chemotherapy:** Patients who achieve a complete remission (no evidence of leukemia remaining) within 4 to 5 weeks of starting therapy tend to have a better prognosis than those in whom this takes longer. Patients who don't achieve a complete remission at all have a poorer outlook. The prognostic value of minimal residual disease (described below) is still being studied.

Status of Acute Lymphocytic Leukemia After Treatment

How well a leukemia responds to treatment has an effect on long-term prognosis.

A *remission (complete remission)* is usually defined as having no evidence of disease after treatment. This means the bone marrow contains fewer than 5% blast cells, the blood cell counts are within normal limits, and there are no signs or symptoms of the disease. A *molecular complete remission* means there is no evidence of leukemia cells in the bone marrow, even when using very sensitive tests, such as PCR.

Minimal residual disease is a term used after treatment when leukemia cells can't be found in the bone marrow using standard tests (such as looking at cells under a microscope), but more sensitive tests (such as flow cytometry or polymerase chain reaction) find evidence that leukemia cells remain in the bone marrow.

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

How Is Acute Lymphocytic Leukemia Treated?

This information represents the views of the doctors and nurses serving on the American Cancer Society's Cancer Information Database Editorial Board. These views are based on their interpretation of studies published in medical journals, as well as their own professional experience.

The treatment information in this document is not official policy of the Society and is not intended as medical advice to replace the expertise and judgment of your cancer care team. It is intended to help you and your family make informed decisions, together with your doctor.

Your doctor may have reasons for suggesting a treatment plan different from these general treatment options. Don't hesitate to ask him or her questions about your treatment options.

This section starts with general comments about types of treatments used for acute lymphocytic leukemia (ALL). This is followed by a discussion of the typical treatment approach for ALL.

Adult acute lymphocytic leukemia (ALL) is not a single disease. It is really a group of related diseases, and patients with different subtypes of ALL vary in their outlook and response to treatment. Treatment options for each patient are based on the leukemia subtype as well as certain prognostic features (described in the previous section).

Several types of treatment may be used in people with ALL. The major therapy is chemotherapy. Surgery and radiation therapy may be used in special circumstances.

Chemotherapy

Chemotherapy is the use of anti-cancer drugs that are injected into a vein, muscle, or cerebrospinal fluid (CSF) or are taken by mouth to destroy or control cancer cells. Except when given into the CSF, these drugs enter the bloodstream and reach all areas of the body, making this treatment useful for cancers such as leukemia that has spread throughout the body.

Chemotherapy for ALL uses a combination of anti-cancer drugs given over a long period of time. The drugs used may include:

- vincristine (Oncovin)
- daunorubicin, also known as daunomycin (Cerubidine)
- doxorubicin (Adriamycin)
- cytarabine, also known as cytosine arabinoside or ara-C (Cytosar)
- L-asparaginase (Elspar), PEG-L-asparaginase (pegaspargase, Oncaspar)
- etoposide (VePesid, others)
- teniposide (Vumon)
- 6-mercaptopurine (Purinethol)
- methotrexate
- cyclophosphamide (Cytoxan)
- prednisone (numerous brand names)
- dexamethasone (Decadron, others)

Chemotherapy drugs work by attacking cells that are dividing quickly, which is why they work against cancer cells. But other cells in the body, such as those in the bone marrow, the

lining of the mouth and intestines, and the hair follicles, also divide quickly. These cells are also likely to be affected by chemotherapy, which can lead to side effects.

The side effects of chemotherapy depend on the type and dose of drugs given and the length of time they are taken. These side effects may include:

- hair loss
- mouth sores
- loss of appetite
- nausea and vomiting
- lowered resistance to infection (due to low white blood cell counts)
- easy bruising or bleeding (due to low blood platelets)
- fatigue (due to low red blood cells)

These side effects are usually short-term and will go away once treatment is finished.

Be sure to talk with your cancer care team about any side effects you have because there are often ways to lessen them. For example, drugs can be given to help prevent or reduce nausea and vomiting.

Drugs known as growth factors (G-CSF and GM-CSF, for example) are sometimes given to increase the white blood cell counts and reduce the chance for infection. Because they may hasten the recovery of the white blood cell count and do not seem to cause any harm, they are often used during chemotherapy in patients with ALL.

If your white blood cell counts are very low during treatment, you can help reduce your risk of infection by carefully avoiding exposure to germs. During this time, your doctor may tell you to:

- Wash your hands often.
- Avoid fresh, uncooked fruits and vegetables and other foods that might carry germs.
- Avoid fresh flowers and plants because they may carry mold.
- Make sure other people wash their hands when they come in contact with you.
- Avoid large crowds and people who are sick (wearing a surgical mask offers protection in these situations).

Antibiotics may be given before there are signs of infection or at the earliest sign that an infection may be developing. The most commonly used antibiotics are a combination of trimethoprim and sulfamethoxazole (Bactrim or Septra), which help fight bacteria. Drugs that help prevent viral and fungal infections may also be given.

Because many of the side effects of chemotherapy are caused by low white blood cell counts, some people find it helpful to keep track of their counts. If you are interested in this, ask your doctor or nurse about your blood cell counts and what these numbers mean.

If your platelet counts are low, you may be given drugs or platelet transfusions to help protect against bleeding. Likewise, shortness of breath and extreme fatigue caused by low red blood cell counts may be treated with drugs or with red blood cell transfusions.

Tumor lysis syndrome is another possible side effect of chemotherapy. It can be seen in patients who had large numbers of leukemia cells in the body before treatment. When chemotherapy kills these cells, they break open and release their contents into the bloodstream, which may affect the kidneys, heart, and nervous system. This can be prevented by giving extra fluids during treatment and by giving certain drugs, such as bicarbonate, allopurinol, and rasburicase, which help the body get rid of these substances.

Organs that could be directly damaged by chemotherapy drugs include the kidneys, liver, testes, ovaries, brain, heart, and lungs. With careful monitoring, such side effects are rare.

If serious side effects occur, the chemotherapy may have to be reduced or stopped, at least for a short time. Careful monitoring and adjustment of drug doses are important because some side effects can be permanent.

One of the most serious side effects of ALL therapy is the increased risk of getting acute myelogenous leukemia (AML) at a later time. This occurs in about 5% of patients after they have received chemotherapy drugs called epipodophyllotoxins (etoposide, teniposide) or alkylating agents (cyclophosphamide, chlorambucil). Less often, people cured of leukemia may later develop non-Hodgkin lymphoma or other cancers. Of course, the risk of getting these second cancers must be balanced against the obvious benefit of treating a life-threatening disease such as leukemia with chemotherapy.

Targeted Therapy

In recent years, new drugs that target specific parts of cancer cells have been developed. Because these drugs are less likely to affect normal cells, their side effects may be less severe than those seen with standard chemotherapy drugs. Some of these may prove to be useful in certain cases of ALL.

For instance, drugs such as imatinib (Gleevec) and dasatinib (Sprycel) have been developed specifically to attack cells that have the Philadelphia chromosome (a shortened chromosome 22 that results from a translocation with chromosome 9).

About 20% to 30% of adult patients with ALL have leukemia cells with this abnormal chromosome. Studies are now being done to find out if these drugs can be combined with chemotherapy to get better outcomes. Early reports have found that more patients seem to have their leukemia disappear and it may not come back as quickly when these drugs are used, but larger studies are needed to confirm this.

Possible side effects of these drugs include diarrhea, nausea, muscle pain, fatigue, and skin rashes. These are generally mild. A common side effect is swelling around the eyes or in the hands or feet. Some studies suggest this fluid buildup may be due to the drugs' effects on the heart. Other possible side effects include lower red blood cell and platelet counts at the start of treatment. All of these side effects get worse at higher than usual doses of the drug.

Surgery

Because leukemia cells spread widely throughout the bone marrow and to many other organs, it is not possible to cure this type of cancer by surgery. Aside from a possible lymph node biopsy, surgery rarely has any role even in the diagnosis, since a bone marrow aspirate and biopsy can usually diagnose leukemia.

Often before treatment is about to start, surgery is needed to insert a small plastic tube, called a central venous catheter or venous access device (VAD), into a large vein. The end of the tube is just under the skin or sticks out in the chest area or upper arm. The VAD is left in place during treatment to take blood samples and give intravenous (IV) drugs such as chemotherapy. This lowers the number of needle sticks needed during treatment. It is very important for the patient to learn how to care for the device to keep it from getting infected.

Radiation Therapy

Radiation therapy uses high-energy radiation to kill cancer cells. External beam radiation therapy focuses high-energy beams on the cancer from a machine outside the body. Getting radiation therapy is much like getting a regular x-ray, although it often takes longer. There are a few instances in which radiation therapy may be used to help treat leukemia:

- Radiation is sometimes used to treat leukemia that has spread to the brain and spinal fluid or to the testicles.
- Radiation to the whole body is often an important part of treatment before a bone marrow or peripheral blood stem cell transplant (see below).
- Radiation is used (rarely) to help shrink a tumor if it is pressing on the trachea (windpipe) and causing breathing problems. But chemotherapy is often used instead, as it may work more quickly.
- Radiation can also be used to reduce pain in an area of bone that is invaded by leukemia, if chemotherapy hasn't helped.

Bone Marrow or Peripheral Blood Stem Cell Transplant

The usual doses of chemotherapy drugs can cause serious side effects to quickly dividing tissues such as the bone marrow. Even though higher doses of these drugs might be more

effective, they are not given because the severe damage to bone marrow cells would cause lethal shortages of blood cells and damage to vital organs.

If the patient is going to have a stem cell transplant (SCT), doctors can use higher doses of chemotherapy and, sometimes, radiation therapy. After treatment is finished, the patient receives a transplant of blood-forming stem cells to restore the bone marrow.

Blood-forming stem cells used for a transplant are obtained either from the blood (for a peripheral blood stem cell transplant, or PBSCT) or from the bone marrow (for a bone marrow transplant, or BMT). Bone marrow transplants were more common in the past, but they have has largely been replaced by PBSCT.

Types of Transplants
There are 2 main types of stem cell transplants: they differ in the source of the blood-forming stem cells.

In an **allogeneic stem cell transplant**, the stem cells come from someone else - usually a donor whose tissue type is almost identical to the patient's. Tissue type is based on certain substances present on the surface of cells in the body. These substances can cause the immune system to react against the cells. Therefore, the closer a tissue "match" is between the donor and the recipient, the better the chance the transplanted cells will "take" and begin making new blood cells.

The donor may be a brother or sister or a matched unrelated donor (MUD). The stem cells from an unrelated donor come from volunteers whose tissue type has been stored in a central registry and matched with the patient’s tissue type. Sometimes umbilical cord stem cells are used. These stem cells come from blood drained from the umbilical cord and placenta after a baby is born and the umbilical cord is cut.

There is an important reason to use allogeneic stem cells (from someone else) for transplantation. These cells seem to help fight any remaining leukemia cells through an immune reaction. This is called a "graft-versus-leukemia" reaction. Studies of this approach are still going on.

Although an allogeneic transplant is the preferred type of transplant for ALL when it is available, its use is limited because of the need for a matched donor. Its use is also limited by its side effects, which are too severe for most people over 55 to 60 years old.

In an **autologous stem cell transplant**, a patient's own stem cells are removed from his or her bone marrow or peripheral blood. They are stored while the person gets treatment (high-dose chemotherapy and/or radiation) and then are reinfused into the patient's blood.

Autologous transplants are sometimes used for people with ALL who are in remission. Some doctors feel that it is better than standard "consolidation" chemotherapy (see below), but not all doctors agree with this.

One problem with autologous transplants is that it is hard to separate normal stem cells from leukemia cells in the bone marrow or blood samples. Even after purging (treating the stem cells in the lab to try to kill or remove any remaining leukemia cells), there is the risk of returning some leukemia cells with the stem cell transplant.

The Transplant Procedure

Blood-forming stem cells from the bone marrow or peripheral blood are collected, frozen, and stored. The patient receives high-dose chemotherapy and sometimes also radiation treatment to the entire body. (Radiation shields are used to protect the lungs, heart, and kidneys from damage during radiation therapy.)

The chemotherapy and radiation treatments are meant to destroy any remaining cancer cells. They also kill the normal cells of the bone marrow and the immune system. This prevents the stem cell transplant (graft) from being rejected. After these treatments, the frozen stem cells are thawed and given as a blood transfusion. The stem cells settle into the patient's bone marrow over the next several days and start to grow and make new blood cells.

In an allogeneic SCT, the person getting the transplant is given drugs such as prednisone and methotrexate or cyclosporine to prevent acute graft-versus-host-disease (GVHD). In this condition, the immune cells in the donor’s marrow or cord blood (the graft) attack the patient’s body (the host). For the next few weeks the patient gets regular blood tests and supportive therapies as needed, which might include antibiotics, red blood cell or platelet transfusions, other medicines, and help with nutrition.

Usually within a couple of weeks after the stem cells have been infused, they begin making new white blood cells. This is followed by new platelet production and, several weeks later, new red blood cell production.

Patients usually stay in the hospital in protective isolation (guarding against exposure to germs) until their white blood cell count rises above 500. They may be able to leave the hospital when their white blood cell count is near 1,000. Because platelet counts take longer to return to a safe level, patients may receive platelet transfusions as an outpatient.

Practical Points

Bone marrow or peripheral blood SCT is a complex treatment. If the doctors think a patient may benefit from a transplant, it should be done at a hospital where the staff has experience with the procedure and with managing the recovery phase. Some bone marrow transplant programs may not have experience in certain types of transplants, especially transplants from unrelated donors.

SCT is very expensive (more than $100,000) and often requires a lengthy hospital stay. Because some insurance companies may view it as an experimental treatment, they may not

pay for the procedure. It is important to find out what your insurer will cover before deciding on a transplant and to have an idea of what you might have to pay.

Side Effects

Side effects from SCT are generally divided into early and long-term effects.

The early complications and side effects are basically the same as those caused by any other type of high-dose chemotherapy (see the Chemotherapy section of this document), and are caused by damage to the bone marrow and other quickly dividing tissues of the body. They can include low blood cell counts (with increased risk of infection and bleeding), nausea, vomiting, loss of appetite, mouth sores, and hair loss.

One of the most common and serious short-term effects is the increased risk for infection from bacteria, viruses, or fungi. Antibiotics are often given to try to prevent infections.. Other side effects, like low red blood cell and platelet counts, may require blood product transfusions or other treatments.

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

- *Graft-versus-host disease* (GVHD), which can occur in allogeneic (donor) transplants. This happens when the donor immune system cells attack tissues of the patient's skin, liver, and digestive tract. Symptoms can include weakness, fatigue, dry mouth, rashes, nausea, diarrhea, yellowing of the skin and eyes (jaundice), and muscle aches. In severe cases, GVHD can be fatal. GVHD is often described as either acute or chronic, based on how soon after the transplant it begins. Drugs that weaken the immune system are often given to try to keep GVHD under control.
- Damage to the lungs, causing shortness of breath
- Damage to the ovaries in women, causing infertility and loss of menstrual periods
- Damage to the thyroid gland that causes problems with metabolism
- *Cataracts* (damage to the lens of the eye that can affect vision)
- Bone damage called *aseptic necrosis* (the bone dies because of poor blood supply); if damage is severe, the patient will need to have part of the bone and the joint replaced.

Graft-versus-host disease is the most serious complication of allogeneic (donor) stem cell transplants. It occurs because the immune system of the patient is taken over by that of the donor. The donor immune system then begins reacting against the patient's other tissues and organs.

The most common symptoms are severe skin rashes and severe diarrhea. The liver and lungs may also be damaged. The patient may also become tired easily and have muscle aches. Sometimes GVHD becomes chronic and disabling and, if it is severe enough, can be fatal. Drugs that affect the immune system may be given to try to control it.

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

Non-myeloablative Transplant (Mini-transplant)

Most patients over the age of 55 will not be able to tolerate a standard allogeneic transplant that uses high doses of chemotherapy. Some, however, may be able to have a non-myeloablative transplant (also known as a mini-transplant or reduced-intensity transplant), where they receive lower doses of chemotherapy and radiation that do not completely destroy the cells in their bone marrow. Then they receive the allogeneic (donor) stem cells. These cells enter the body and establish a new immune system, which sees the leukemia cells as foreign and attacks them (a "graft-versus-leukemia" effect).

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

This procedure is still considered experimental, but is being studied to determine how useful it may be against ALL.

For more information on stem cell transplants, see the American Cancer Society document, Bone Marrow & Peripheral Blood Stem Cell Transplants.

Clinical Trials

You have had to make a lot of decisions since you've been told you have cancer. One of the most important decisions you will make is deciding which treatment is best for you. You may have heard about clinical trials being done for your type of cancer. Or maybe someone on your health care team has mentioned a clinical trial to you. Clinical trials are one way to get state-of-the art cancer care. Still, they are not right for everyone.

Here we will give you a brief review of clinical trials. Talking to your health care team, your family, and your friends can help you make the best treatment choice for you.

What Are Clinical Trials?

Clinical trials are carefully controlled research studies that are done with patients. These studies test whether a new treatment is safe and how well it works in patients, or they may test new ways to diagnose or prevent a disease. Clinical trials have led to many advances in cancer prevention, diagnosis, and treatment.

The Purpose of Clinical Trials

Clinical trials are done to get a closer look at promising new treatments or procedures in patients. A clinical trial is only done when there is good reason to believe that the treatment, test, or procedure being studied may be better than the one used now. Treatments used in clinical trials are often found to have real benefits and may go on to become tomorrow's standard treatment.

Clinical trials can focus on many things, such as:

- new uses of drugs that are already approved by the US Food and Drug Administration (FDA)
- new drugs that have not yet been approved by the FDA
- non-drug treatments (such as radiation therapy)
- medical procedures (such as types of surgery)
- herbs and vitamins
- tools to improve the ways medicines or diagnostic tests are used
- medicines or procedures to relieve symptoms or improve comfort
- combinations of treatments and procedures

Researchers conduct studies of new treatments to try to answer the following questions:

- Is the treatment helpful?
- What's the best way to give it?
- Does it work better than other treatments already available?
- What side effects does the treatment cause?
- Are there more or fewer side effects than the standard treatment used now?
- Do the benefits outweigh the side effects?
- In which patients is the treatment most likely to be helpful?

Phases of Clinical Trials

There are 4 phases of clinical trials, which are numbered I, II, III, and IV. We will use the example of testing a new cancer treatment drug to look at what each phase is like.

Phase I clinical trials: The purpose of a phase I study is to find the best way to give a new treatment safely to patients. The cancer care team closely watches patients for any harmful side effects.

For phase I studies, the drug has already been tested in lab and animal studies, but the side effects in patients are not fully known. Doctors start by giving very low doses of the drug to the first patients and increase the doses for later groups of patients until side effects appear or the desired effect is seen. Doctors are hoping to help patients, but the main purpose of a phase I trial is to test the safety of the drug.

Phase I clinical trials are often done in small groups of people with different cancers that have not responded to standard treatment, or that keep coming back (recurring) after

treatment. If a drug is found to be reasonably safe in phase I studies, it can be tested in a phase II clinical trial.

Phase II clinical trials: These studies are designed to see if the drug works. Patients are given the best dose as determined from phase I studies. They are closely watched for an effect on the cancer. The cancer care team also looks for side effects.

Phase II trials are often done in larger groups of patients with a specific cancer type that has not responded to standard treatment. If a drug is found to be effective in phase II studies, it can be tested in a phase III clinical trial.

Phase III clinical trials: Phase III studies involve large numbers of patients -- most often those who have just been diagnosed with a specific type of cancer. Phase III clinical trials may enroll thousands of patients.

Often, these studies are randomized. This means that patients are randomly put in one of two (or more) groups. One group (called the control group) gets the standard, most accepted treatment. Another group (or more than one group) will get the new treatment being studied. All patients in phase III studies are closely watched. The study will be stopped early if the side effects of the new treatment are too severe or if one group has much better results than the others.

Phase III clinical trials are usually needed before the FDA will approve a treatment for use by the general public.

Phase IV clinical trials: Once a drug has been approved by the FDA and is available for all patients, it is still studied in other clinical trials (sometimes referred to as phase IV studies). This way more can be learned about short-term and long-term side effects and safety as the drug is used in larger numbers of patients with many types of diseases. Doctors can also learn more about how well the drug works, and if it might be helpful when used in other ways (such as in combination with other treatments).

What It Will Be Like to Be in a Clinical Trial

If you are in a clinical trial, you will have a team of experts taking care of you and watching your progress very carefully. Depending on the phase of the clinical trial, you may receive more attention (such as having more doctor visits and lab tests) than you would if you were treated outside of a clinical trials. Clinical trials are specially designed to pay close attention to you.

However, there are some risks. No one involved in the study knows in advance whether the treatment will work or exactly what side effects will occur. That is what the study is designed to find out. While most side effects go away in time, some may be long-lasting or even life threatening. Keep in mind, though, that even standard treatments have side effects. Depending on many factors, you may decide to enter (enroll in) a clinical trial.

Deciding to Enter a Clinical Trial

If you would like to take part in a clinical trial, you should begin by asking your doctor if your clinic or hospital conducts clinical trials. There are requirements you must meet to take part in any clinical trial. But whether or not you enter (enroll in) a clinical trial is completely up to you.

Your doctors and nurses will explain the study to you in detail. They will go over the possible risks and benefits and give you a form to read and sign. The form says that you understand the clinical trial and want to take part in it. This process is known as giving your informed consent. Even after reading and signing the form and after the clinical trial begins, you are free to leave the study at any time, for any reason.

Taking part in a clinical trial does not keep you from getting any other medical care you may need.

To find out more about clinical trials, talk to your cancer care team. Here are some questions you might ask:

- Is there a clinical trial that I could take part in?
- What is the purpose of the study?
- What kinds of tests and treatments does the study involve?
- What does this treatment do? Has it been used before?
- Will I know which treatment I receive?
- What is likely to happen in my case with, or without, this new treatment?
- What are my other choices and their pros and cons?
- How could the study affect my daily life?
- What side effects can I expect from the study? Can the side effects be controlled?
- Will I have to stay in the hospital? If so, how often and for how long?
- Will the study cost me anything? Will any of the treatment be free?
- If I am harmed as a result of the research, what treatment would I be entitled to?
- What type of long-term follow-up care is part of the study?
- Has the treatment been used to treat other types of cancers?

How Can I Find Out More About Clinical Trials That Might Be Right for Me?

The American Cancer Society offers a clinical trials matching service for patients, their family, and friends. You can reach this service at 1-800-303-5691 or on our Web site at http://clinicaltrials.cancer.org.

Based on the information you give about your cancer type, stage, and previous treatments, this service can put together a list of clinical trials that match your medical needs. The service will also ask where you live and whether you are willing to travel so that it can look for a treatment center that you can get to.

You can also get a list of current clinical trials by calling the National Cancer Institute's Cancer Information Service toll free at 1-800-4-CANCER (1-800-422-6237) or by visiting the NCI clinical trials Web site at www.cancer.gov/clinicaltrials.

For even more information on clinical trials, the American Cancer Society has a document called *Clinical Trials: What You Need to Know.* You can read this on the Web site, www.cancer.org, or have it sent to you by calling 1-800-ACS-2345.

Complementary and Alternative Therapies

When you have cancer you are likely to hear about ways to treat your cancer or relieve symptoms that are different from mainstream (standard) medical treatment. These methods can include vitamins, herbs, and special diets, or methods such as acupuncture or massage—among many others. You may have a lot of questions about these treatments. Here are some you may have thought of already:

- How do I know if a non-standard treatment is safe?
- How do I know if it works?
- Should I try one or more of these treatments?
- What does my doctor know/think about these methods? Should I tell the doctor that I'm thinking about trying them?
- Will these treatments cause a problem with my standard medical treatment?
- What is the difference between "complementary" and "alternative" methods?
- Where can I find out more about these treatments?

The Terms Can Be Confusing

Not everyone uses these terms the same way, so it can be confusing. The American Cancer Society uses *complementary* to refer to medicines or methods that are used *along with* your regular medical care. *Alternative* medicine is a treatment used *instead of* standard medical treatment.

Complementary Methods

Complementary methods, for the most part, are not presented as cures for cancer. Most often they are used to help you feel better. Some methods that can be used in a complementary way are meditation to reduce stress, acupuncture to relieve pain or aromatherapy or peppermint tea to relive nausea. There are many others. Some of these methods are known to help, while others have not been tested. Some have been proven not be helpful. A few have even been found harmful. However, some of these methods may add to your comfort and well-being.

There are many complementary methods that you can safely use right along with your medical treatment to help relieve symptoms or side effects, to ease pain, and to help you

enjoy life more. For example, some people find methods such as aromatherapy, massage therapy, meditation, or yoga to be useful.

Alternative Methods

Alternative methods are those that are used instead of standard medical care. These treatments have not been proven safe and effective in clinical trials. Some of these methods may even be dangerous and some have life-threatening side effects. The main danger with trying any of these is that you may lose the chance to benefit from standard treatment. Delays or interruptions in your standard medical treatment may give the cancer more time to grow. Most of these methods are not covered by insurance.

Deciding What to Do

It is easy to see why people with cancer may consider alternative methods. You want to do all you can to fight the cancer. Sometimes mainstream treatments such as chemotherapy can be hard to take, or they may no longer be working.

Sometimes people suggest that their method can cure your cancer without having serious side effects, and it's normal to want to believe them. But the truth is that most non-standard methods of treatment have not been tested and proven to be effective for treating cancer. As you consider your options, here are 3 important steps you can take:

- Talk to your doctor or nurse about any method you are thinking about using.
- Check the list of "red flags" below.
- Contact the American Cancer Society at 1-800-ACS-2345 to learn more about complementary and alternative methods in general and to learn more about the specific methods you are thinking about.

Red Flags

You can use the questions below to spot treatments or methods to avoid. A "yes" answer to any one of these questions should raise a "red flag."

- Does the treatment promise a cure for all or most cancers?
- Are you told not to use standard medical treatment?
- Is the treatment or drug a "secret" that only certain people can give?
- Does the treatment require you to travel to another country?
- Do the promoters attack the medical or scientific community?

The Decision Is Yours

Decisions about how to treat or manage your cancer are always yours to make. If you are thinking about using a complementary or alternative method, be sure to learn about the

method and talk to your doctor about it. With reliable information and input from your health care team, you may be able to safely use the methods that can help you while avoiding those that could be harmful.

Typical Treatment of Acute Lymphocytic Leukemia

The main treatment for ALL involves the long-term use of chemotherapy. In the last several years, doctors have begun to use more intensive chemotherapy regimens, and more patients have responded well.. But these regimens are also more likely to cause side effects, such as low white blood cell counts. Patients may need to take other drugs to help prevent or treat these side effects.

Treatment typically takes place in 3 phases:

- remission induction
- consolidation (intensification)
- maintenance

The total treatment usually takes about 2 years, with the maintenance phase taking up most of this time. Treatment may be more or less intense, depending on the subtype of ALL and other prognostic factors.

An important part of treatment of ALL is central nervous system (CNS) prophylaxis -- treatment that is meant to ensure the leukemia does not spread to (or remain in) the brain or spinal cord. This is described in more detail below.

Remission Induction

The initial phase of chemotherapy usually lasts for a month or so, and typically includes the following drugs:

- vincristine
- dexamethasone or prednisone
- doxorubicin (Adriamycin) or daunorubicin

Based on the patient's prognostic factors, some regimens may also include cyclophosphamide, L-asparaginase, etoposide, and/or high doses of methotrexate or cytarabine (ara-C) as part of the induction phase. For ALL patients who have the Philadelphia chromosome, targeted drugs such as imatinib (Gleevec) are often included as well.

Treatment to keep the leukemia cells from spreading to the CNS is often started at this time. This may include one or more of the following:

- intrathecal chemotherapy (injected directly into the spinal fluid) with methotrexate, and sometimes with cytarabine or a steroid such as prednisone
- high-dose IV methotrexate

- radiation therapy to the brain

Consolidation (Intensification)

If the patient goes into remission, the next phase often consists of fairly short course of chemotherapy, using many of the same drugs that were used for induction therapy. This may be a single course over one month or up to 3 courses over 3 months. Usually the drugs are given in high doses so that the treatment is still fairly intense. CNS prophylaxis may be continued at this time.

Some patients who go into remission are still at high risk for relapse, such as those who have certain subtypes of ALL or other poor prognostic factors. Doctors may suggest an allogeneic stem cell transplant (SCT) at this time, especially for those who have a brother or sister who would be a good donor match. An autologous SCT may be another option. The possible risks and benefits of stem cell transplants need to be weighed carefully, as it's still not clear how helpful they are. Patients considering this procedure may best be served by having it done in the context of a clinical trial at a center that has done a lot of SCT procedures..

Maintenance

After consolidation, the patient is generally put on a maintenance chemotherapy program of methotrexate and 6-mercaptopurine (6-MP). In some cases, this may be combined with other drugs such as vincristine and prednisone. Maintenance usually lasts for about 2 years. CNS prophylaxis may be continued at this time.

Some doctors feel that maintenance therapy may not be needed for some leukemias such as T-cell ALL and mature B-cell ALL (Burkitt leukemia).

Response Rates

In general, about 70% to 90% of patients will respond completely to these treatments. That means leukemia cells can no longer be seen in their bone marrow. Unfortunately, about half of these patients relapse, so the overall cure rate is around 30% to 40%. Again, this varies depending on the subtype of ALL and other prognostic factors. One of the most important is whether the cells contain the Philadelphia chromosome, in which case the cure rate will likely be lower.

What if the Leukemia Doesn't Respond or Comes Back After Treatment?

If the leukemia is refractory -- that is, if it doesn't go away with the first treatment (which happens in about 15% to 20% of cases) -- then newer or more intensive doses of drugs may be tried, although they are less likely to work. A stem cell transplant may be tried if the

leukemia can be put into at least partial remission. Clinical trials of new treatment approaches may also be considered.

If leukemia comes back (recurs) after initial treatment, it will most often do so in the bone marrow and blood. Occasionally, the brain or spinal fluid will be the first place it recurs.

In these cases, it is sometimes possible to put the leukemia into remission again with more chemotherapy, although this remission is not likely to last. For ALL patients with the Philadelphia chromosome, switching to or adding a newer targeted drug such as dasatinib (Sprycel) may be helpful. If a second remission can be achieved, most doctors will advise some type of stem cell transplant if possible.

If the leukemia doesn't go away or keeps coming back, eventually chemotherapy treatment will not be very helpful. If a stem cell transplant is not an option, a patient may want to consider taking part in a clinical trial of newer treatments.

Those who want to continue treatment to fight the leukemia as long as they can, need to consider the odds of more treatment having any benefit. In many cases, the doctor can estimate the response rate for the treatment being considered. Some people are tempted to try more chemotherapy, for example, even when their doctors say that the odds of benefit are less than 1%. In this situation, it is important to think about and understand the reasons for choosing this plan.

Palliative Treatment

If a clinical trial is not an option, it is important at this time to focus on relieving the symptoms of the leukemia. This is known as palliative treatment. The doctor may advise less intensive chemotherapy to try to slow the leukemia growth instead of trying to cure it.

As the leukemia grows in the bone marrow it may cause pain. It is important to treat it with radiation or appropriate pain-killing medicines. If medicines such as aspirin and ibuprofen don't help with the pain, stronger opioid medicines such as morphine are likely to be helpful.

Other common symptoms from leukemia are low blood counts and fatigue. Medicines or blood transfusions may be needed to help correct these problems. Nausea and loss of appetite can be treated with medicines and high calorie food supplements. Infections that occur may be treated with antibiotics.

At some point, a patient may benefit from hospice care. Most of the time, this can be given at home. The leukemia may be causing symptoms or problems that need attention, and hospice focuses on the patient's comfort. Receiving hospice care doesn't mean you can't have treatment for the problems caused by the cancer or other health conditions. It just means that the focus of care is on living life as fully as possible and feeling as well as one can at this difficult stage.

Remember also that maintaining hope is important. The hope for a cure may not be as bright, but there is still hope for good times with family and friends -- times that can bring happiness and meaning. In a way, pausing at this time in your cancer treatment is an opportunity to refocus on the most important things in your life. This 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.

More Treatment Information

For more details on treatment options -- including some that may not be addressed in this document -- the National Cancer Institute (NCI) is a good source of information.

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

What Should You Ask Your Doctor About Acute Lymphocytic Leukemia?

As you cope with cancer and cancer treatment, you need to have honest, open discussions with your doctor. You should 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. Nurses, social workers, and other members of the treatment team may also be able to answer many of your questions.

- What kind of acute lymphocytic leukemia do I have?
- Are there any specific factors that might affect my prognosis?
- What treatment choices do I have?
- Which treatment do you recommend, and why?
- What side effects are there to the treatments that you recommend?
- What can I do to help reduce the side effects I may have from the chemotherapy?
- Should we consider a stem cell transplant? When?
- What are the chances that my leukemia will come back once I am in remission?
- What is the outlook for my survival?

Be sure to write down any questions you have that are not on this list. For instance, you might want specific information about recovery times so that you can plan your work schedule. Or you may want to ask about second opinions or about clinical trials for which you may qualify. Taking another person and/or a tape recorder to the appointment can be helpful. Getting copies of your medical records, pathology reports, and radiology reports may be useful in case you wish to seek a second opinion at a later time.

What Happens After Treatment for Acute Lymphocytic Leukemia?

Completing treatment can be both stressful and exciting. You will be relieved to finish treatment, yet it is hard not to worry about the leukemia coming back. This is a very common concern among those who have had cancer.

It may take a while before your confidence in your own recovery begins to feel real and your fears are somewhat relieved. Even with no recurrences, people who have had cancer learn to live with uncertainty.

Follow-up Care

You will need frequent follow-up exams for several years after the treatment for acute lymphocytic leukemia (ALL) is finished. These follow-up visits are very important. Your doctor will continue to watch for signs of recurrent disease, as well as for short-term and long-term side effects of treatment. It is important that you report any new symptoms to your doctor right away, so that the cause can be determined and treated, if needed.

Checkups are likely to include careful physical exams, lab tests, and imaging tests when needed. A benefit of follow-up care is that it gives you a chance to discuss questions and concerns that can arise during and after your recovery.

If a relapse occurs, it is usually while the patient is being treated or shortly after they have finished chemotherapy. If this happens, treatment would be as described in the section, What if the Leukemia Doesn't Respond or Comes Back After Treatment? It is unusual for ALL to return if there are still no signs of the disease 5 years after treatment.

Seeing a New Doctor

At some point after your cancer diagnosis and treatment, you may find yourself in the office of a new doctor. Your original doctor may have moved or retired, or you may have moved or changed doctors for some reason. It is important that you be able to give your new doctor the exact details of your diagnosis and treatment. Make sure you have the following information handy:

- a copy of your pathology report from any biopsy or surgery
- if you had surgery, a copy of your operative report
- if you were hospitalized, a copy of the discharge summary that every doctor must prepare when patients are sent home from the hospital
- finally, since some drugs can have long-term side effects, a list of your drugs, drug doses, and when you took them

Lifestyle Changes to Consider During and After Treatment

Having cancer and dealing with treatment can be time-consuming and emotionally draining, 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. Some people even begin this process during cancer treatment.

Make Healthier Choices

Think about your life before you learned you had cancer. Were there things you did that might have made you less healthy? Maybe you drank too much alcohol, or ate more than you needed, or smoked, or didn't exercise very often. Emotionally, maybe you kept your feelings bottled up, or maybe you let stressful situations go on too long.

Now is not the time to feel guilty or to blame yourself. However, you can start making changes today that can have positive effects for the rest of your life. Not only will you feel better but you will also be healthier. What better time than now to take advantage of the motivation you have as a result of going through a life-changing experience like having cancer?

You can start by working on those things that you feel most concerned about. Get help with those that are harder for you. For instance, if you are thinking about quitting smoking and need help, call the American Cancer Society's Quitline® tobacco cessation program at 1-800-ACS-2345.

Diet and Nutrition

Eating right can be a challenge for anyone, but it can get even tougher during and after cancer treatment. For instance, treatment often may change your sense of taste. Nausea can be a problem. You may lose your appetite for a while and lose weight when you don't want to. On the other hand, some people gain weight even without eating more. This can be frustrating, too.

If you are losing weight or have taste problems during treatment, do the best you can with eating and remember that these problems usually improve over time. You may want to ask your cancer team for a referral to a dietitian, an expert in nutrition who can give you ideas on how to fight some of the side effects of your treatment. You may also find it helps to eat small portions every 2 to 3 hours until you feel better and can go back to a more normal schedule.

One of the best things you can do after treatment is to put healthy eating habits into place. You will be surprised at the long-term benefits of some simple changes, like increasing the variety of healthy foods you eat. Try to eat 5 or more servings of vegetables and fruits each day. Choose whole grain foods instead of white flour and sugars. Try to limit meats that are high in fat. Cut back on processed meats like hot dogs, bologna, and bacon. Get rid of them altogether if you can. If you drink alcohol, limit yourself to 1 or 2 drinks a day at the most. And don't forget to get some type of regular exercise. The combination of a good diet and

regular exercise will help you maintain a healthy weight and keep you feeling more energetic.

Rest, Fatigue, Work, and Exercise

Fatigue is a very common symptom in people being treated for cancer. This is often not an ordinary type of tiredness but a “bone-weary” exhaustion that doesn’t get better with rest. For some, this fatigue lasts a long time after treatment, and can discourage them from physical activity.

However, exercise can actually help you reduce fatigue. Studies have shown that patients who follow an exercise program tailored to their personal needs feel physically and emotionally improved and can cope better.

If you are ill and need to be on bed rest during treatment, it is normal to expect your fitness, endurance, and muscle strength to decline some. Physical therapy can help you maintain strength and range of motion in your muscles, which can help fight fatigue and the sense of depression that sometimes comes with feeling so tired.

Any program of physical activity should fit your own situation. An older person who has never exercised will not be able to take on the same amount of exercise as a 20-year-old who plays tennis 3 times a week. If you haven't exercised in a few years but can still get around, you may want to think about taking short walks.

Talk with your health care team before starting, and get their opinion about your exercise plans. Then, try to get an exercise buddy so that you're not doing it alone. Having family or friends involved when starting a new exercise program can give you that extra boost of support to keep you going when the push just isn’t there.

If you are very tired, though, you will need to balance activity with rest. It is okay to rest when you need to. It is really hard for some people to allow themselves to do that when they are used to working all day or taking care of a household. (For more information about fatigue, please see the publication, Cancer Related Fatigue and Anemia Treatment Guidelines for Patients.)

Exercise can improve your physical and emotional health.
It improves your cardiovascular (heart and circulation) fitness.
It strengthens your muscles.
It reduces fatigue.
It lowers anxiety and depression.
It makes you feel generally happier.
It helps you feel better about yourself.

And long term, we know that exercise plays a role in preventing some cancers. The American Cancer Society, in its guidelines on physical activity for cancer prevention, recommends that adults take part in at least 1 physical activity for 30 minutes or more on 5 days or more of the week. Children and teens are encouraged to try for at least 60 minutes a day of energetic physical activity on at least 5 days a week.

How About Your Emotional Health?

Once your treatment ends, you may find yourself overwhelmed by emotions. This happens to a lot of people. You may have been going through so much during treatment that you could only focus on getting through your treatment.

Now you may find that you think about the potential of your own death, or the effect of your cancer on your family, friends, and career. You may also begin to re-evaluate your relationship with your spouse or partner. Unexpected issues may also cause concern -- for instance, as you become healthier and have fewer doctor visits, you will see your health care team less often. That can be a source of anxiety for some.

This is an ideal time to seek out emotional and social support. You need people you can turn to for strength and comfort. Support can come in many forms: family, friends, cancer support groups, church or spiritual groups, online support communities, or individual counselors.

Almost everyone who has been through cancer can benefit from getting some type of support. What's best for you depends on your situation and personality. Some people feel safe in peer-support groups or education groups. Others would rather talk in an informal setting, such as church. Others may feel more at ease talking one-on-one with a trusted friend or counselor. Whatever your source of strength or comfort, make sure you have a place to go with your concerns.

The cancer journey can feel very lonely. It is not necessary or realistic to go it all by yourself. And your friends and family may feel shut out if you decide not 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-ACS-2345 and we can put you in touch with an appropriate group or resource.

You can't change the fact that you have had cancer. What you can change is how you live the rest of your life -- making healthy choices and feeling as well as possible, physically and emotionally.

What's New in Acute Lymphocytic Leukemia Research and Treatment?

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

Genetics of Leukemia

Scientists are making progress in understanding how changes in a person's DNA can cause normal bone marrow cells to develop into leukemia. A greater understanding of the genes (regions of the DNA) involved in certain translocations that often occur in acute lymphocytic leukemia (ALL) is providing insight into why these cells become abnormal.

As this information unfolds, it may be used in developing newer targeted therapies against ALL. Drugs such as imatinib (Gleevec) and dasatinib (Sprycel) are examples of such treatments. They are now being studied for use in treating ALL patients who have the Philadelphia chromosome.

Gene Expression Profiling

This new lab technique is being studied to help identify and classify different cancers. Instead of looking at single genes, this test uses a special technology to look at the patterns of many different genes in the cancer cells at the same time. This type of test is now being looked at to help classify cases of ALL into different risk categories. This may add to the information that comes from the standard molecular genetic studies.

Detecting Minimal Residual Disease

Progress in understanding DNA changes in ALL has already provided a highly sensitive test for detecting minimal residual disease after treatment -- when so few leukemia cells are present that they cannot be found by routine bone marrow tests.

The polymerase chain reaction (PCR) test can identify ALL cells based on their gene translocations or rearrangements. This test can find one leukemia cell among a million normal cells. A PCR test can be useful in determining how completely the chemotherapy has destroyed the ALL 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 Chemotherapy

Studies are currently in progress to find the most effective combination of chemotherapy drugs while still avoiding unwanted side effects. New drugs are being developed and tested. Studies are also under way to determine whether patients with certain unfavorable prognostic features benefit from more intensive chemotherapy, and whether some ALL patients with favorable prognostic factors might not need as much treatment.

The effectiveness of chemotherapy may be limited in some cases because the leukemia cells become resistant to it. Researchers are now looking at ways to prevent or reverse this resistance by using other drugs along with chemotherapy.

Stem Cell Transplants

Studies continue to refine this procedure to increase effectiveness, reduce complications, and determine which patients are most likely to be helped by this treatment.

Monoclonal Antibodies

These are man-made immune system proteins that attach to certain molecules on the surface of the leukemia cells. One of them, called rituximab (Rituxan), is used to treat lymphomas that contain a molecule called CD20. Some ALL cells also contain this molecule. Researchers are now studying whether rituximab might be helpful against these cells. Early results have been favorable, but it is still too early to know for sure. Studies of several other monoclonal antibodies to treat ALL are now under way as well.

Additional Resources

More Information from Your American Cancer Society

We have selected some related information that may also be helpful to you. These materials may be ordered from our toll-free number, 1-800-ACS-2345.

After Diagnosis: A Guide for Patients and Families (Available in Spanish also)

Caring for the Patient with Cancer at Home (Available in Spanish also)

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

The following books are available from the American Cancer Society. Call us at 1-800-ACS-2345 to ask about costs or to place your order.

American Cancer Society's Guide to Pain Control

Cancer in the Family: Helping Children Cope with a Parent's Illness

Caregiving: A Step-By-Step Resource for Caring for the Person with Cancer at Home

Coming to Terms with Cancer: A Glossary of Cancer-Related Terms

Consumers Guide to Cancer Drugs

Informed Decisions, Second Edition: The Complete Book of Cancer Diagnosis, Treatment, and Recovery

National Organizations and Web Sites*

In addition to the American Cancer Society, other sources of patient information and support include:

Caitlin Raymond International Registry (for unrelated bone marrow transplants)
Telephone: 1-800-726-2824
Internet Address: www.crir.org

Leukemia & Lymphoma Society
Telephone: 1-800-955-4572 or 1-914-949-5213
Internet: www.lls.org

Leukemia Links
Internet Address: www.acor.org/leukemia/

National Bone Marrow Transplant Link (nbmtLink)
Telephone: 1-800-LINK-BMT (1-800-546-5268)
Internet Address: www.nbmtlink.org

National Cancer Institute
Telephone: 1-800-4-CANCER (1-800-422-6237)
Internet Address: www.cancer.gov

National Marrow Donor Program
Telephone: 1-800-MARROW-2 (1-800-627-7692)
Internet Address: www.marrow.org

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

The American Cancer Society is happy to address almost any cancer-related topic. If you have any more questions, please call us at 1-800 ACS 2345 at any time, 24 hours a day.

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For additional assistance please contact your American Cancer Society
1 · 800 · ACS·2345 or www.cancer.org