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Acute Lymphoblastic Leukemia

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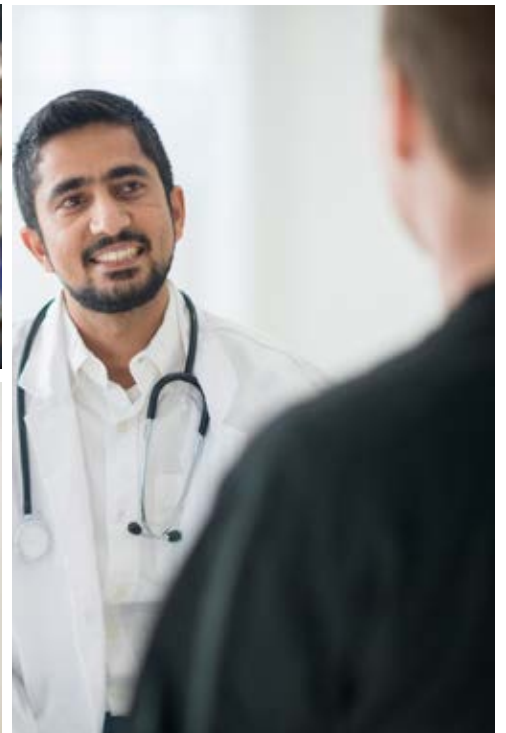
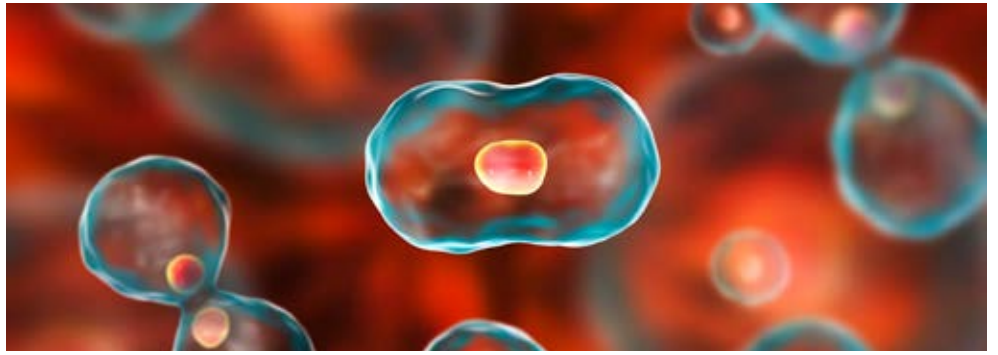
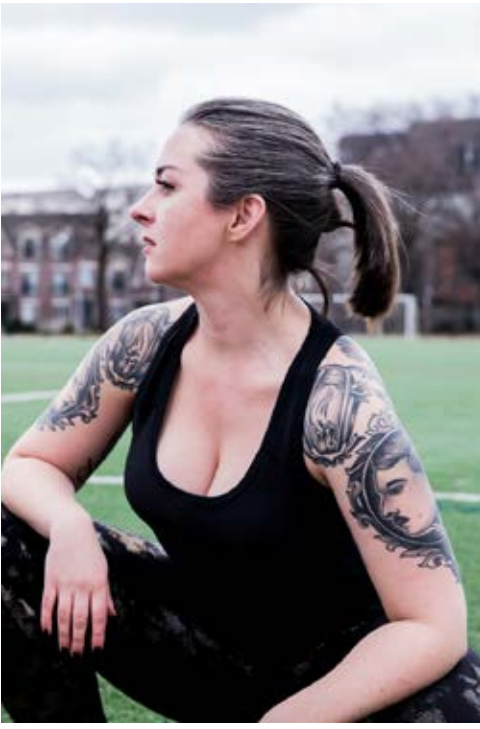
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The Leukemia & Lymphoma Society

The Leukemia & Lymphoma Society (LLS) is dedicated to developing better outcomes for blood cancer patients through research, education and patient services and is happy to have this comprehensive resource available to patients. [LLS.org/information-specialists](https://lls.org/information-specialists)

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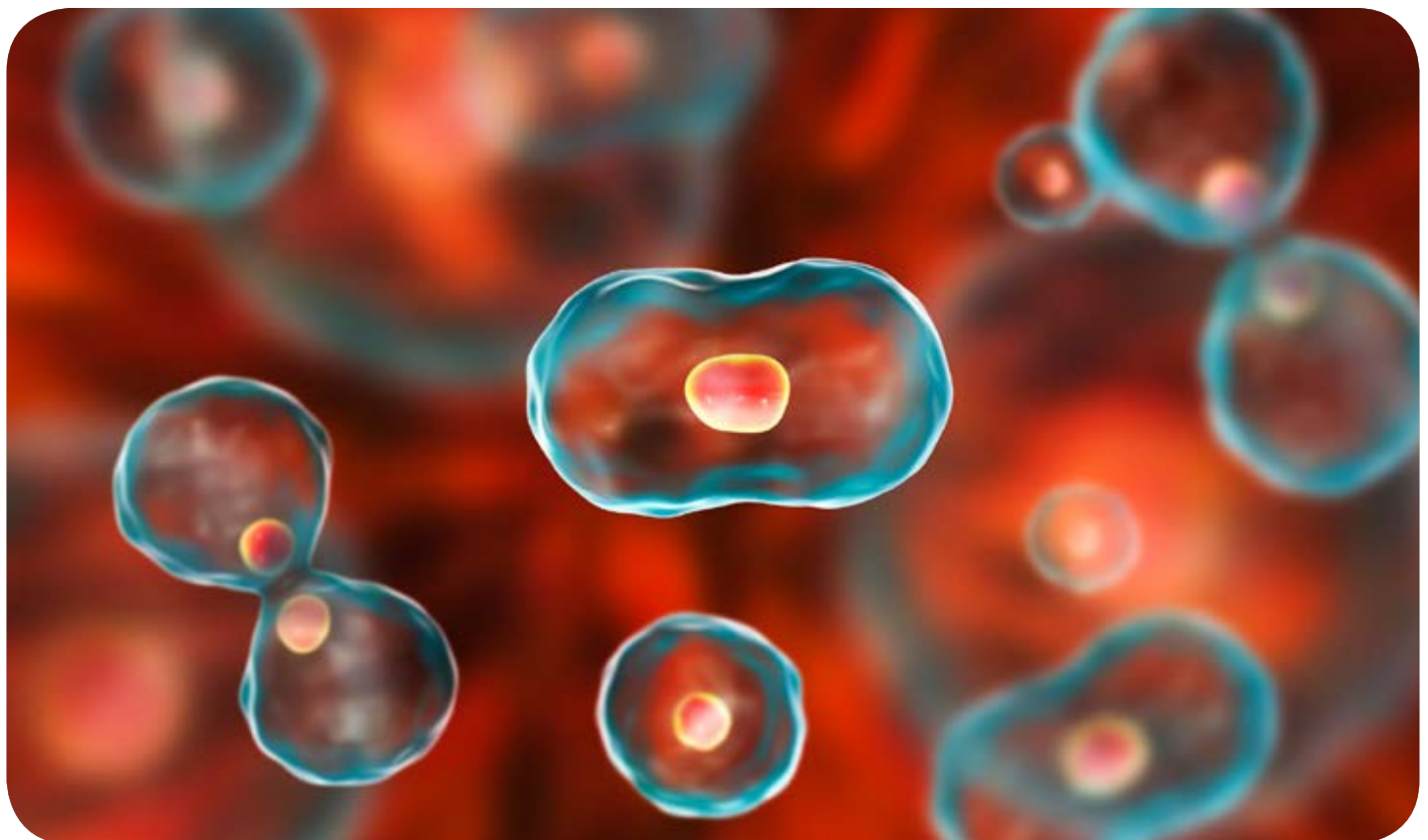
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1

ALL basics

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You've learned that you have or may have leukemia. It's common to feel shocked and confused. This chapter reviews some basics that may help you learn about acute lymphoblastic leukemia.

Blood

To learn about ALL (**a**cute **l**ymphoblastic **l**eukemia), you first must know about blood. Blood is one of the fluids in the body. It consists of blood cells that move within a liquid called plasma. Plasma is mostly water.

Blood cells

There are three main types of blood cells. One type is red blood cells (also called erythrocytes). Another type is white blood cells (leukocytes). The third type is platelets (thrombocytes).

Blood cells have important jobs. Red blood cells carry oxygen throughout the body. White blood cells help fight germs. Platelets help control bleeding.

Most blood cells are formed in bone marrow. Bone marrow is the sponge-like tissue in the center of most bones. Within marrow are blood stem cells from which all blood cells are formed.

Stem cells make new cells that are a step closer to being a mature blood cell. These early cells are called progenitor cells. Unlike stem cells, progenitor cells are set to become a certain type of blood cell.

Lymphoblasts

As shown in **Figure 1**, lymphoid progenitor cells start one branch of the blood cell family tree. They form into cells called lymphoblasts (blasts, for short). Blasts are very young blood cells that can't function like mature blood cells.

Over time, lymphoblasts form into fully mature white blood cells called lymphocytes. Lymphocytes include B cells, T cells, and natural killer cells. B cells make antibodies that mark germs for killing. T cells alert your body that germs are present, kill diseased cells, and help B cells. Natural killer cells release chemicals that kill diseased cells.

Lymphocytes form in marrow and are released into the bloodstream. From the bloodstream, they are

released into tissue. They return to the bloodstream through the lymph system.

The lymph system consists of fluid, called lymph, and a network of tissues. Lymph travels in lymph vessels and passes through lymph nodes, which filter out germs and waste. Other organs of the lymph system include the thymus, spleen, and tonsils.

Figure 1
Blood cells

Blood stem cells are the cells from which all blood cells are formed. They make two types of progenitor cells. Lymphoid progenitor cells form into white blood cells called lymphocytes. Common myeloid progenitor cells form into red blood cells, platelets, and white blood cells called granulocytes.

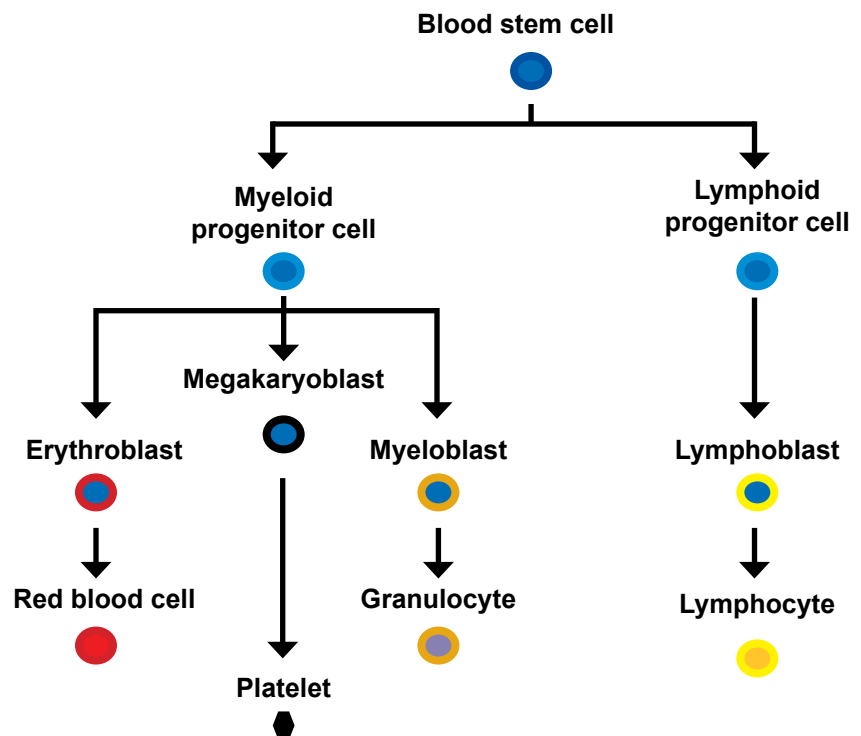


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A disease of cells

Your body is made of trillions of cells. Cancer is a disease of cells. Each type of cancer is named after the normal cell from which it formed.

Leukemia

Leukemia is a cancer of blood cells. A lot of people call it blood cancer. The four main types of leukemia are ALL, AML (**a**cute **m**yeloid leukemia), CLL (**c**hronic **l**ymphocytic leukemia), and CML (**c**hronic **m**yeloid leukemia). Acute leukemias often grow fast. Chronic leukemias often grow slow.

ALL

ALL is a cancer that consists of abnormal lymphoblasts. It can be either B-cell or T-cell type. ALL and lymphoblastic lymphoma are thought to be

the same cancer. But, most cancer cells are in the blood and bone for ALL and in the lymph nodes for lymphoblastic lymphoma. Treatment of these cancers is very similar.

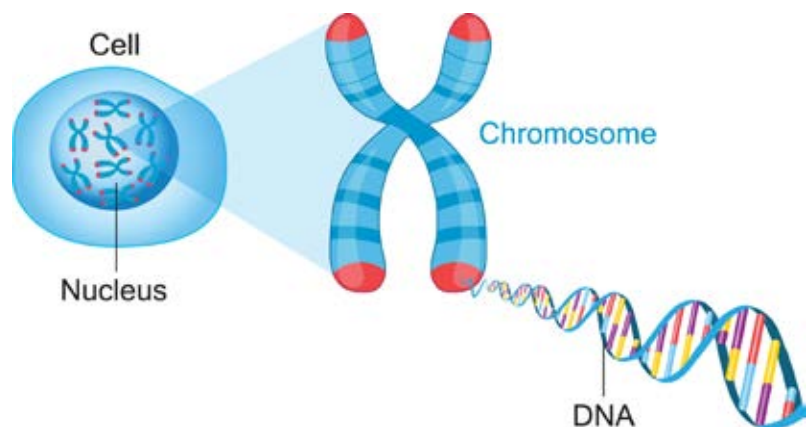
ALL occurs in people of all ages. It is most common in children. It also occurs in adults, especially those older than 60 years of age. The focus of this book is the treatment of ALL for people 15 years of age and older.

Mutations

Cells have a control center called the nucleus. The nucleus contains chromosomes, which are long strands of DNA (**d**eoxy**r**ibonucleic acid) tightly wrapped around proteins. **See Figure 2.** Within DNA are coded instructions for building new cells and

Figure 2 Genetic material in cells

Most human cells contain a plan called the “blueprint of life.” It is a plan for how our bodies are made and work. It is found inside of chromosomes. Chromosomes are long strands of DNA that are tightly wrapped around proteins. Genes are small pieces of DNA. Humans have about 20,000 to 25,000 genes.



controlling how cells behave. These instructions are called genes.

There can be abnormal changes in genes called mutations. In people with cancer, mutations are usually present only in cancer cells. Some types of mutations that are linked to cancer can be present in all cells. Mutations cause cancer cells to not behave like normal cells and, sometimes, to look very different from normal cells.

ALL's threat

The signs and symptoms of leukemia result from a lack of mature blood cells. Without mature blood cells, health problems will occur. Some of these health problems may be severe.

As the number of leukemia cells rises, the number of normal cells decreases in the marrow. Low numbers of red blood cells is called anemia. Anemia may cause you to feel tired and look pale. You may also have headaches and problems breathing.

A shortage of platelets may cause bleeding. You may get nose bleeds. Your gums may bleed easily. Your skin may bruise. If you have menstrual periods, you may have heavy bleeding. Bleeding from ALL can be fatal.

You may have frequent infections if you have too few white blood cells. Infections may be mild or severe. They can be fatal.

In ALL, leukemia cells can spread outside of bone marrow. They can spread within the lymph system to lymph nodes and the spleen. They can also spread to the liver, spine, and brain. Although rare, ALL can spread to the skin, mouth, kidneys, and testicles. Once inside of organs, the leukemia cells may crowd out normal cells and cause organ failure.

Tests for ALL

Tests of bone marrow or blood are needed to confirm (diagnose) ALL. A bone marrow aspiration removes a small amount of liquid bone marrow. A bone marrow biopsy removes a small piece of bone. These procedures are done at the same time.

Blood and tissue samples will be sent to a doctor called a hematopathologist. These doctors spend much of their time looking at samples of blood, bone marrow, and lymph nodes. So, they become experts at diagnosing blood cancers.

Lymphoblast count

The number of lymphoblasts in your marrow or blood will be counted. Diagnosis of ALL requires at least 20% of cells in marrow to be blasts. A blood sample may be used instead of marrow but only if there are enough blasts in the blood.

The cancerous blasts have to be copies (clones) of the same “parent” cancerous cell. This is called monoclonality. Features of the clones will be noted to help assess the outlook (prognosis) and choice of treatment. The hematopathologist will assess the type of disease, such as B-cell or T-cell ALL.

Protein tests

For diagnosis, the hematopathologist will study which proteins are present in the cell and on the cells' surface (membrane). This is called immunophenotyping. ALL and its subtypes can have common patterns or “signature” surface proteins. For example, ALL is called CD20-positive when many of the blasts have CD20 surface proteins.

Genetic tests

Genetic tests show abnormal changes in genes and chromosomes within cells. ALL and its subtypes have certain genetic changes and lack others. Results of genetic tests are used to predict the outcome of ALL and plan treatment.

The Philadelphia chromosome

A cell must make a copy of its 23 chromosomes before dividing into 2 cells. Sometimes, there are mistakes in the copies. One type of mistake is when parts of two chromosomes switch with each other. This is called a translocation. It can cause two genes to attach and form an abnormal fusion gene.

BCR-ABL1 is a common fusion gene in B-cell ALL. During the translocation, the *ABL1* gene on chromosome 9 attaches to the *BCR* gene on chromosome 22. This abnormal chromosome 22 is called the Philadelphia chromosome. **See Figure 3.**

When ALL has the Philadelphia chromosome, it is called Ph-positive ALL. Ph-positive ALL occurs more often in older people than younger people. Ph-positive ALL is treated the same as Ph-negative ALL.

Pathology report

Lab results used for diagnosis are included in a pathology report. This report will be sent to your doctor. Ask him or her for a copy. Your doctor will review the results with you. Take notes and ask questions.

Figure 3
Philadelphia chromosome

The Philadelphia chromosome is formed by a translocation between parts of chromosomes 9 and 22. It contains the abnormal *BCR-ABL1* fusion gene.

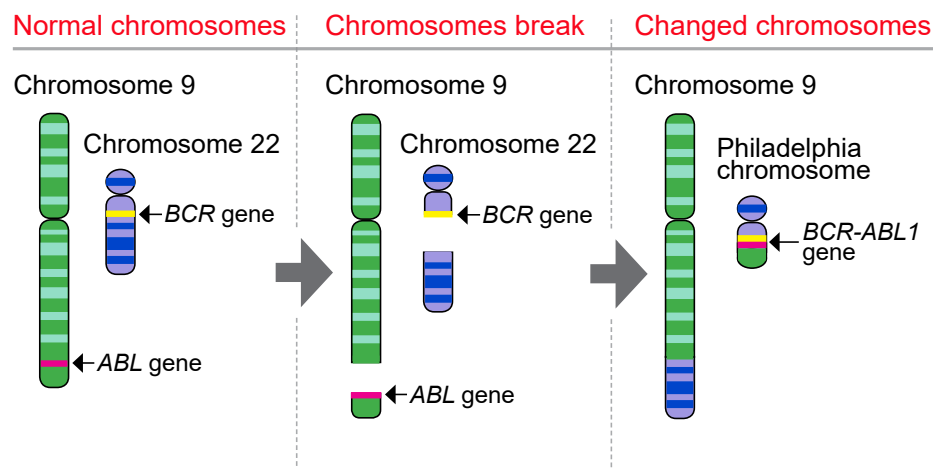


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Treatment types

Not everyone with ALL receives the same treatment. Your doctor will tailor treatment to you based on tests described in **Part 2**. Treatment for ALL has three main phases called induction, consolidation, and maintenance. Options for each phase are listed in **Part 3** based on cancer features and your age and health.

Clinical trial

One treatment choice may be a clinical trial. Joining a clinical trial is strongly supported by NCCN. NCCN believes that you will receive the best management if treated in a clinical trial.

A clinical trial is a type of research that studies a promising test or treatment in people. It gives people access to health care that otherwise couldn't usually be received. Ask your treatment team if there is an open clinical trial that you can join.

Chemotherapy

Chemotherapy works by damaging and killing cancer cells. It can also cause cells to destroy themselves. There are many types of chemotherapy used to treat ALL.

Vincristine belongs in a class of drugs called vinca alkaloids. Anthracyclines include daunorubicin and doxorubicin. Cyclophosphamide belongs to a class called alkylating agents. Antimetabolites include methotrexate, cytarabine, and 6-MP (6-mercaptopurine). Asparaginase is an enzyme.

Corticosteroids

Corticosteroids are a class of drugs that are often used to relieve inflammation. They also are toxic to ALL cells. Prednisone and dexamethasone are the two main corticosteroids used for treatment.

Tyrosine kinase inhibitors

Within cells, kinases are part of many chemical pathways, some of which control cell growth. They change the action of proteins by attaching phosphates to them. In Ph-positive ALL, the *BCR-ABL1* gene makes an abnormal tyrosine kinase that helps the leukemia cells grow.

TKIs (tyrosine kinase inhibitors) are drugs that block the transfer of phosphate. They include imatinib, dasatinib, nilotinib, bosutinib, and ponatinib. These drugs work well at stopping growth signals. ALL cells die and fewer cancer cells are made.

Antibody treatment

Antibodies are proteins of the immune system. They help your body fight germs and other threats. Monoclonal antibodies can be made in a lab to treat certain types of cancer. They attach to cells to mark them for destruction by your immune system. They may also directly kill cells.

To date, there are three antibody treatments that are often used for ALL. Rituximab treats CD20-positive ALL. Blinatumomab allows normal T cells to attack cancerous B cells by bringing them close together. Inotuzumab ozogamicin is an antibody-drug conjugate. It binds to CD22 on leukemia cells then releases a toxic agent once it's inside the cells.

CAR T-cell immunotherapy

Tisagenlecleucel is made from your own T cells. Your T cells will be removed from your body, and in the lab, CAR (chimeric antigen receptor) will be added to them. This programs the T cells to find leukemia cells. The programmed T cells will be infused back into your body to find and kill cancer cells.

Stem cell transplant

A stem cell transplant replaces unhealthy stem cells with healthy ones. An allogeneic transplant uses healthy stem cells from a donor. Testing is needed to find a donor who's a good match for you.

An allogeneic transplant is an intense treatment, so not everyone can get it.

You'll first receive treatment to kill your bone marrow and most ALL cells. Next, you'll receive the donor cells. These cells will form new, healthy marrow. They will also attack cancer cells that weren't killed by prior treatment. Visit the websites listed in **Part 4** for more information on transplants.

Radiation therapy

Radiation therapy uses high-energy x-rays to treat ALL in the brain. The x-rays damage DNA in cancer cells. This either kills the cancer cells or stops new cancer cells from being made.

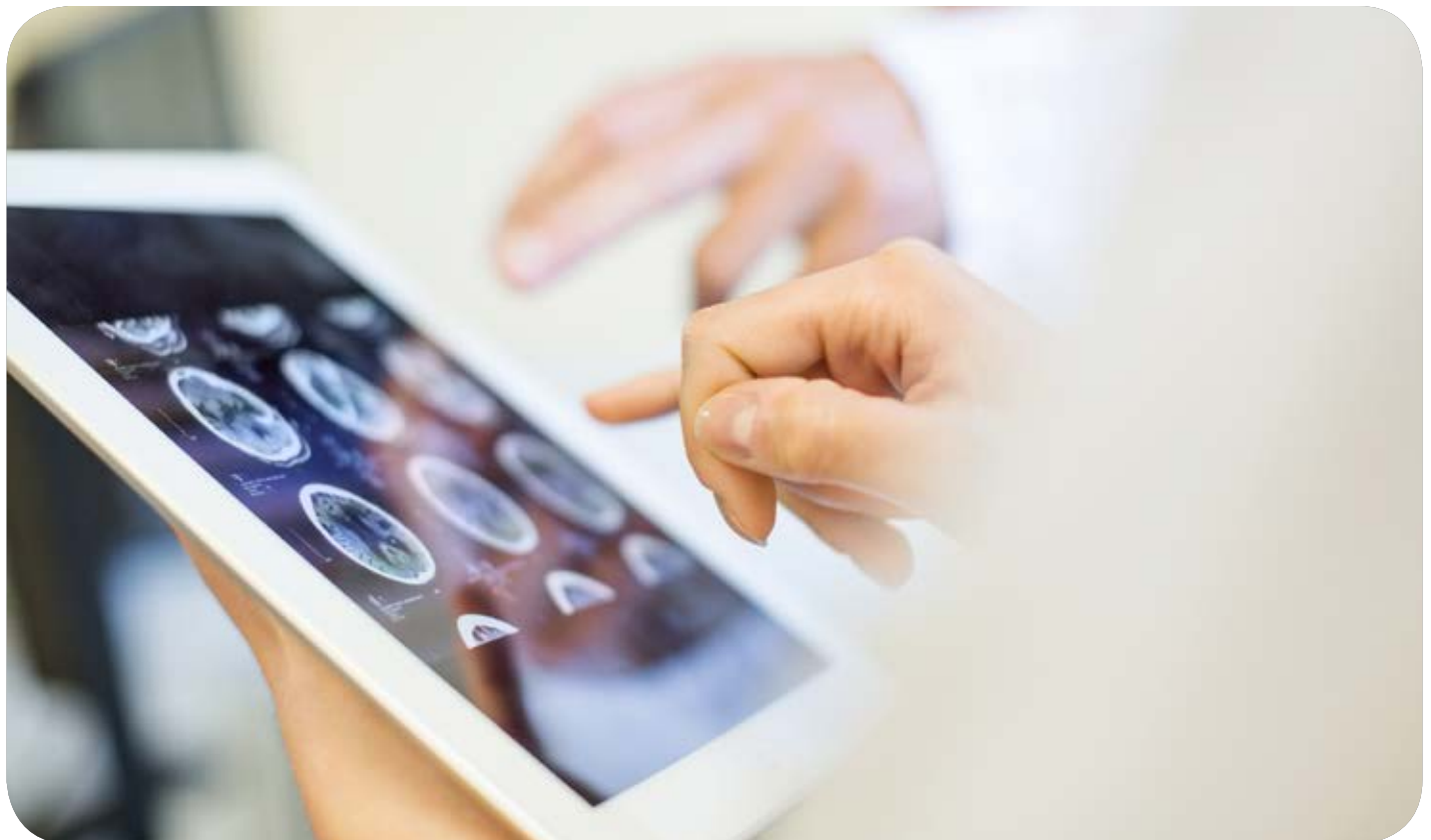
Review

- White blood cells are a part of your body's immune system. Lymphoblasts are a type of young white blood cells. They form into three types of lymphocytes—B cells, T cells, and natural killer cells.
- Leukemias are cancers of blood cells. ALL is a leukemia of abnormal lymphoblasts.
- Your bone marrow or blood needs to be tested to diagnose ALL. Doctors look for very high numbers of lymphoblasts. They also look for proteins that are common and uncommon to ALL cells.
- Clinical trials give people access to new tests and treatments that they otherwise couldn't have received.
- There are many types of treatment for ALL including chemotherapy, corticosteroids, TKIs, and monoclonal antibodies.

2

Treatment planning

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Your doctors want to learn all about the leukemia you have. This chapter describes who should receive which tests before cancer treatment. It also describes other types of care needed before treatment.

Doctors plan treatment using many sources of information. These sources include the health care listed in [Guide 1](#). Another source is you. Tell your doctor your concerns and goals for treatment. Together, you can share in the decision-making process. Read **Part 4** to learn more about making treatment decisions.

Medical history

Your doctor will ask about any health problems and their treatment during your lifetime. Be prepared to tell what illnesses and injuries you have had. You will also be asked about health conditions and symptoms. It may help to bring a list of old and new medicines to your doctor's office.

Some cancers and other health conditions can run in families. Thus, your doctor will ask about the medical history of your close blood relatives. Such family includes your siblings, parents, and grandparents. Be prepared to tell who has had what diseases and at what ages.

Physical exam

A physical exam is a study of your body. It is done to look for signs of disease. It is also used to help assess what treatments may be options.

Guide 1. Health care before cancer treatment

Must haves

- Medical history
- Physical exam
- CBC with differential
- Chemistry profile
- Liver function tests
- Coagulation tests
- Urinalysis
- TLS panel
- Screening for opportunistic infections
- Hepatitis B/C, CMV, HIV tests
- Scrotal ultrasound if needed
- Head CT or MRI if symptoms present
- Neck, chest, abdomen, pelvis imaging if symptoms present; PET/CT to assess lymph nodes and organs if needed
- Echocardiogram or cardiac nuclear medicine scan
- Central venous access device for chemotherapy
- Lumbar puncture for chemotherapy
- HLA typing if needed
- Fertility support if wanted
- Pregnancy test if you can have babies

To start, your basic body functions will be measured. These functions include your temperature, blood pressure, and pulse and breathing rate. Your weight and height will also be checked.

Your doctor will listen to your lungs, heart, and gut. He or she will also assess your eyes, skin, nose, ears, and mouth. ALL sometimes spreads to and damages the skin.

Parts of your body will be felt. Tell your doctor if you feel pain when touched. Your doctor will note the size of organs and if organs feel soft or hard. ALL can enlarge the spleen and lymph nodes. It can also cause a mass to form in men's testicles.

Your doctor will rate your performance status. Performance status is your ability to do daily activities. It is used by doctors to assess if you can have certain treatments.

Blood tests

Doctors test blood to look for signs of disease. Blood tests require a sample of your blood. Blood samples can be removed with a blood draw.

Blood draw

Some blood draws require no eating and drinking for hours. Your doctor will say if you can eat or drink. Blood samples will be removed from a vein with a needle.

CBC with differential

A CBC (complete blood count) measures parts of the blood. Test results include counts of white blood cells, red blood cells, and platelets. Cancer and other health problems can cause low or high counts.

There are several types of white blood cells. A differential counts the number of each type of cell. It also checks if the counts are in balance with each other.

Chemistry profile

Chemicals in your blood come from your liver, bone, and other organs. A chemistry profile measures the levels of these chemicals. Abnormal results may be a sign that an organ or body system isn't working well. Such organs include your liver and kidneys.

Liver function tests

Your liver is an organ in the upper right side of your abdomen. It does many important jobs, such as remove toxins from your blood. Liver function tests assess for proteins and chemicals that are made or processed by the liver. There may be abnormal results if ALL is growing in the liver.

Blood clotting tests

Your body stops bleeding by turning blood into a gel-like form. The gel-like blood forms into a solid mass called a blood clot. Proteins, called coagulation factors, are needed for clotting. They are made by the liver.

An impaired clotting process is common in leukemia. You may have bleeding and bruises. There are four tests that assess for clotting problems.

- **Prothrombin time** is a measure of how well all coagulation factors work together.
- **Partial thromboplastin time** assesses coagulation factors from two of three pathways.
- **Fibrinogen activity** is a measure of how much fibrinogen—a blood protein—is being made.
- **D-dimer** is a protein fragment that is released when a blood clot dissolves.

Urine tests

The contents of your urine will be tested before starting treatment. This is called urinalysis. Results may be used to assess if you have an infection. They may also be used to assess how well your kidneys are working. ALL can but rarely spreads to the kidneys.

TLS panel

With ALL, the leukemia cells make new cells quickly. In this process, they can release unsafe acids and high levels of potassium and phosphate. Treatment of ALL can cause the same unsafe release from cells.

The released chemicals from leukemia cells can cause TLS (**tumor lysis syndrome**). TLS can be life threatening. It can be severe at the time of diagnosis and during the early phases of treatment.

A TLS panel can help your doctor assess if you are likely to get TLS or have active TLS. It measures lactate dehydrogenase, uric acid, potassium, calcium, and phosphorus. A blood sample is needed for testing. You may receive treatments to lower your chance of getting TLS.

Infectious disease tests

An infectious disease is an illness caused by germs like viruses, bacteria, and fungi. You are more likely to get infections due to ALL and its treatment. Infections can also be more severe than usual in people with ALL. Chronic infections are a concern, too. Some can become active again after certain cancer treatments.

Opportunistic infection screening

Opportunistic infections occur due to a weakened immune system. Because of ALL and its treatment, you are at risk for these infections. Some infections may be prevented with medicine. Your doctor will also screen for infections and provide treatment when needed.

Hepatitis B/C, CMV, HIV tests

Hepatitis B and C, CMV (**cytomegalovirus**), and HIV (**human immunodeficiency virus**) often require treatment during intense cancer treatment. These infections need treatment even if they are causing few symptoms. Tell your treatment team if you have one or more of these infections. If you're unsure, testing is advised. A sample of your blood is needed for testing.

Imaging

Imaging makes pictures of the insides of your body. It is often used to detect where cancer is in the body. A radiologist is a doctor who is an expert in reading images. He or she will convey the test results to your doctor.

Scrotal ultrasound

ALL can spread to a man's testicles. You may receive an ultrasound of your scrotum if needed. The radiologist will look for a mass in the pictures.

Head CT or MRI

ALL can spread to the spinal cord and brain. Your doctor will order a CT (computed tomography) or MRI (magnetic resonance imaging) if you have certain signs or symptoms. Contrast dye should be used. It makes the pictures clearer.

Neck, chest, abdomen, pelvis CT scan

ALL can spread to lymph nodes and organs. If you have certain symptoms, your doctor may order imaging of your neck, chest, abdomen, and pelvis. Injection of contrast into a vein should be used. Your doctor may order CT with PET (positron emission tomography) to assess lymph nodes or organs. This imaging is called a PET/CT scan.

Preparing for chemotherapy

Chemotherapy is a very common treatment for ALL. It is often injected into the bloodstream and spinal fluid. To receive chemotherapy, you will need these procedures.

Heart test

Some cancer treatments can damage your heart. To plan treatment, your doctor may test how well your heart pumps blood. Testing may be very helpful if you have had heart problems.

You may get an echocardiogram or cardiac nuclear medicine scan. An echocardiogram uses sound waves to make pictures of your heart. A nuclear medicine scan makes pictures using a radiotracer and special camera.

Central venous access device

Chemotherapy is given over a prolonged period of time. There are devices that make getting chemotherapy easier. The device may be a catheter, port, or pump. It will be inserted into a large vein during a minor surgery and remain in your body until treatment is done.

Lumbar puncture

Leukemia cells in spinal fluid may or may not cause symptoms. To confirm their presence or absence, a fluid sample must be removed and tested. A lumbar puncture is a procedure that removes spinal fluid. It is also called a spinal tap. **See Figure 4.**

A lumbar puncture is also used to inject chemotherapy into spinal fluid. Often, a lumbar puncture is not needed before the first day of chemotherapy. If you have certain symptoms, it may be done early to assess if leukemia cells are present.

HLA typing

HLAs (**h**uman **l**eukocyte **a**ntigens) are proteins found on the surface of most cells. They are markers of your body's cells. Your body detects these markers to tell which cells are its own.

HLAs do not differ between cells within a person. In other words, all your cells have the same set of HLAs. Each person's set of HLAs is called the HLA type or tissue type.

HLA typing is a test that detects a person's HLA type. This test is needed if a transplant of blood stem cells from a donor may be a treatment option. It may be helpful to do HLA typing early to find a donor. Blood samples from you and your family members will be tested.

Fertility and pregnancy

Some cancer treatments can limit your ability to have a baby. If you want the choice of having babies after treatment or are unsure, tell your doctors. It may also help to talk with a fertility specialist before you begin cancer treatment.

A fertility specialist is an expert in helping people have babies. The fertility specialist can discuss with you how to have a baby after treatment. Some methods of fertility preservation are discussed next. If you are a woman of childbearing age, important information on pregnancy is also addressed.

Sperm banking

Men who want to have children after cancer treatment can use sperm banking. Sperm banking stores semen for later use. This is done by freezing semen with sperm in liquid nitrogen. Talk to your

Figure 4 Lumbar puncture

A lumbar puncture is used to remove a sample of spinal fluid. The fluid will be tested for leukemia. A lumbar puncture may also be used to inject cancer drugs into spinal fluid.

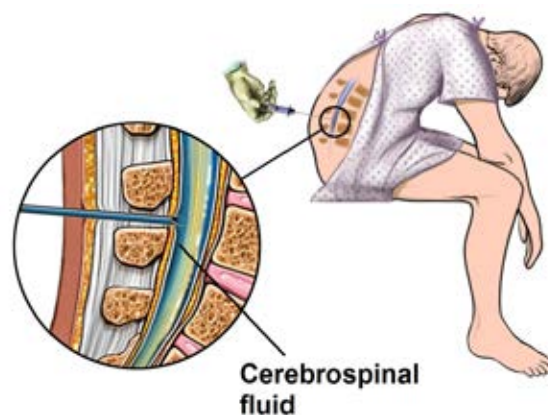


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treatment team about the costs of and how well sperm banking works.

Egg freezing

Like sperm banking, a woman's eggs can be removed, frozen, and stored for later use. Your frozen eggs can be fertilized with sperm beforehand. Also, a part of your ovary that contains eggs can be frozen and stored.

Pregnancy test

Some cancer treatments can harm an unborn baby. Get a pregnancy test before treatment if you may be pregnant now. Your treatment options will depend on the results.

Birth control

During treatment, take steps to avoid getting pregnant. Your doctors can tell you which birth control methods are best to use.

- ALL puts you at risk for infectious diseases. Screening for infection is needed for timely treatment. Chronic infections like hepatitis and HIV need to be treated in order to safely receive strong cancer treatments.
- Imaging tests allow your doctors to see inside your body without cutting into it. Men may get an ultrasound of their testicles. Based on signs or symptoms, you may receive imaging of your head or torso.
- You may need to prepare for chemotherapy by getting a heart test, an access device, and a lumbar puncture.
- HLA typing is needed if you will receive a transplant of blood stem cells from a donor.
- Talk to a fertility specialist to learn about ways to have babies after cancer treatment. If you may be pregnant, get a pregnancy test now. Some cancer treatments can harm unborn babies.

Review

- Your doctor will ask you about any health problems and treatment in your lifetime.
- Your doctor will study your body to assess your health. He or she will check the size of your organs. Your doctor will also look for signs of ALL in your skin, mouth, and in men, the testicles.
- Blood tests will be done to look for signs of health problems. Blood clotting tests will also be done.
- A urine test can help assess the health of your kidneys and other organs.
- TLS can be a life-threatening outcome of ALL or its treatment. A panel of tests can help your doctor assess if you are at risk.

3

Treatment guide

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This chapter presents the treatment options for ALL. It also reviews care for when treatment has ended. Discuss with your doctor which options are right for you.

Overview

Treatment of ALL includes treatment of the cancer and support for you. At this time, ALL is not cured in many adolescents and adults. Instead, the aim of treatment is to reduce symptoms, control the cancer, and extend life. These outcomes have improved in recent years because of research on the disease and treatment.

Initial treatment

Treatment for ALL is complex. There are three main phases of treatment. During treatment, you will likely receive more than one type of drug. The doses and timing of the drugs will differ. You will also receive care for treatment side effects. If you can, get treated by experts in ALL given how complex treatment is.

Treatment results

During and at the end of treatment, you will receive tests to assess the results. These tests include physical exams and blood tests. The types of treatment response are:

- **Complete remission** is the absence of cancer signs and symptoms for at least four weeks. No leukemia cells are seen in your bone marrow. Lymphoblasts are not detectable in your bloodstream, body tissue, and nervous system. Enlarged organs and lymph nodes are back to normal size. Blood counts are within normal range.
- **MRD (minimal residual disease)** is a small number of leukemia cells in bone marrow despite a complete remission. It is also called measurable residual disease. The cells are found by molecular lab tests that can find “a needle in a haystack.”
- **Refractory disease** is cancer that is not in remission at the end of the first phase of treatment.
- **Progressive disease** is a worsening of the cancer. It is defined by a large increase in blasts within the marrow or blood or the spread of blasts to body tissue.
- **Relapsed disease** is the return of cancer after it’s been in remission. It is defined by a large number of blasts in bone marrow or blood or the spread of blasts to body tissue.

Survivorship

In most people, ALL is in remission at the end of treatment. The next step of care is to follow your survivorship care plan. These plans include tests to assess for relapse. Your survivorship care plan will also include help for your general health and for healthy living.

Relapsed or refractory ALL

About 1 out of 10 people have refractory ALL. About half of remissions relapse. Most relapses happen within two years after initial treatment. Treatment for relapsed and refractory disease is similar. Cure or long-term cancer control can be achieved for some people.

Initial treatment

Initial treatment has three main phases. The first phase is called induction treatment (or remission induction). The second phase is called consolidation treatment and may include intensification treatment. The third phase is called maintenance treatment. Treatment options for the three phases are described in this section.

ALL can spread to the central nervous system. This system consists of your spinal cord and brain. In most people, ALL has not spread to the central nervous system by the start of treatment.

There is treatment that can help stop ALL from spreading to the central nervous system. This treatment is often started during induction. Treatment may be injected into your bloodstream, cerebrospinal fluid, or both. Methotrexate and cytarabine are often used.

Induction

The options for induction treatment are listed in [Guide 2](#). Induction often lasts about 4 weeks. You may need to stay in the hospital for most of these four weeks.

The goal of induction is to clear leukemia cells from bone marrow. At the end of treatment, doctors allow normal bone marrow to recover and make blood. The cancer may be in remission. If not, you may receive more induction treatment.

Clinical trial

Joining a clinical trial may be an option. Ask your doctor if there is a clinical trial that is right for you. Clinical trials can help answer these questions:

- Which current treatments work the best?
- Are there treatments that work better for one person than another?

- Are all the drugs in a complex treatment needed?
- Is there a new treatment that cures ALL in more people?
- How long should maintenance treatment be?

Chemotherapy

Chemotherapy is a very common treatment. Although common, there is not one standard regimen but many. Treatment typically includes vincristine, an anthracycline, and a corticosteroid. Asparaginase, cyclophosphamide, or both may be added.

Your doctor will choose your treatment based on many factors. One factor is the type of ALL that you have. If you have Ph-negative ALL, your treatment options depend on if you have B- or T-cell ALL. Also, rituximab may be added to treatment if the ALL is CD20 positive. For Ph-positive ALL, a TKI is added to chemotherapy. TKI stands for tyrosine kinase inhibitor.

Treatment for ALL is also based on age. Most treatment studies have enrolled either “children” or “adults.” The ages included in these age groups

Guide 2. Induction

What are the options?

- Clinical trial
- Chemotherapy
 - Rituximab may be added if CD20-positive ALL
 - TKI is added if Ph-positive ALL
 - Less intense drugs are used for frail people
- Corticosteroids
 - TKI is added if Ph-positive ALL

TKI = tyrosine kinase inhibitor

IN DEPTH: Induction chemotherapy regimens

Ph-negative ALL

Adolescents and young adults

Preferred regimens:

- CALGB 10403
- COG AALL0232
- COG AALL0434 + nelarabine for T-cell ALL
- DFCI ALL
- GRAALL-2005 ± rituximab
- PETHEMA ALL-96

Other regimens:

- Hyper-CVAD ± rituximab
- USC ALL
- Linker 4-drug regimen

Fit adults

- CALGB 8811 Larson
- GRAALL-2005 ± rituximab
- Hyper-CVAD ± rituximab
- Linker 4-drug regimen
- MRC UKALLXII/ECOG2993

Frail adults

- Vincristine + prednisone
- Prednisone, vincristine, methotrexate, and 6-mercaptopurine
- GMALL
- ALLOLD07
- GRAALL
- Modified DFCI 91-01
- Hyper-CVAD with dose-reduced cytarabine
- CALGB 9111

Ph-positive ALL

Adolescents and young adults

- EsPhALL with imatinib or dasatinib
- (Ponatinib, imatinib, or dasatinib) + hyper-CVAD
- (Imatinib, nilotinib, or dasatinib) + multiagent chemotherapy
- (Imatinib, dasatinib, or nilotinib) + vincristine + dexamethasone

Fit adults

- (Ponatinib, imatinib, or dasatinib) + hyper-CVAD
- (Imatinib or nilotinib) + multiagent chemotherapy
- (Imatinib, dasatinib, or nilotinib) + vincristine + dexamethasone

Frail adults

- (Imatinib, dasatinib, or nilotinib) ± corticosteroids
- (Dasatinib or imatinib) + vincristine + dexamethasone
- EWALL
- (Dasatinib or ponatinib) + hyper-CVAD with dose-reduced cytarabine

have differed across studies. Adolescents and young adults (15 to 39 years of age) have been included in both age groups. The preferred option for adolescents and young adults is the intense treatment used for children. Strong adult regimens may provide similar results.

Another deciding factor for treatment is your level of fitness. If you are frail, some treatments may be harmful to your health. Your doctor will assess your level of fitness based on your age and overall health. If you are frail, you may receive low-intensity chemotherapy. It has good results in the short term and side effects are less severe. But, more treatment will be needed to keep the cancer in remission.

Corticosteroids

When chemotherapy can't be used, a corticosteroid may be an option. It is a lower-intensity treatment that is sometimes given to older adults or adults who are quite sick. For Ph-negative ALL, a corticosteroid may be used to relieve symptoms. For Ph-positive ALL, a corticosteroid may be used with a TKI for treatment. More treatment will be needed to keep the cancer in remission.

Consolidation

The options for consolidation are listed in [Guide 3](#). Consolidation starts after there is a complete remission. The goal of treatment is to increase the chance of cure. Consolidation may last from 4 to 8 months.

To plan treatment, you will need to have a bone marrow aspiration. A sample of your liquid marrow will be tested for MRD. MRD is a major risk of relapse.

Keep taking chemotherapy

For many people, chemotherapy is used for consolidation. In general, chemotherapy used for induction is used for consolidation. Rituximab may be

added to treatment if the ALL is CD20 positive. If the cancer is Ph-positive, a TKI will be added.

Allogeneic transplant

Not everyone can have an allogeneic stem cell transplant. It is an intense treatment, so it may be harmful to some people. Getting a transplant also depends on having a donor and the proper social support.

If a transplant is an option, your doctor will assess how helpful it will likely be. For Ph-positive ALL, a transplant may not work better than a TKI with intense chemotherapy among people 21 years of age and younger. For Ph-negative ALL, a transplant may be most helpful if relapse is likely.

If you will have a transplant, the best time to have it is unknown. If you are healthy enough, you may receive more treatment for MRD beforehand.

Blinatumomab

Blinatumomab may be an option for Ph-negative, B-cell ALL. It is used to treat MRD. After treatment, your doctor may advise getting an allogeneic stem cell transplant.

Guide 3. Consolidation

What are the options?

- Keep taking chemotherapy
 - Rituximab may be added if CD20-positive ALL
 - TKI is added if Ph-positive ALL
- Allogeneic stem cell transplant
- Blinatumomab to treat MRD of Ph-negative, B-cell ALL

TKI = tyrosine kinase inhibitor; MRD = minimal residual disease

Maintenance

The goal of maintenance is to stop ALL from coming back. Treatment often lasts for 2 to 3 years. It is given in an outpatient setting.

During maintenance, your doctor may test for MRD. If there is no MRD, testing should not occur more often than every three months. If MRD is present, testing may occur more often.

After transplant

For Ph-negative ALL, there is not a maintenance phase of treatment after a transplant. For Ph-positive ALL, maintenance with a TKI may reduce your chance for a relapse. But, more research is needed. The TKI should be taken for at least 1 year, but studies are needed to learn the best length of time.

After chemotherapy

For Ph-negative ALL, treatment includes weekly methotrexate, daily 6-MP, and monthly pulses of vincristine and prednisone. The length of maintenance depends on the regimen. If on 6-MP, you doctor may test the function of your *TPMT* gene. This gene can affect how well 6-MP works and its side effects.

For Ph-positive ALL, a TKI will be part of maintenance for at least one year. More research is needed to learn how long TKI maintenance should be. Imatinib, dasatinib, nilotinib, or ponatinib may be an option.

Besides a TKI, you will receive monthly pulses of vincristine and prednisone for 2 to 3 years. Weekly methotrexate and daily 6-MP may be added. If on 6-MP, you doctor may test the function of your *TPMT* gene. This gene can affect how well 6-MP works and its side effects.



Supportive care

Supportive care aims to improve your quality of life. It includes care for health issues caused by cancer or cancer treatment. It is also sometimes called palliative care. Palliative care is important for everyone, not just people at the end of life.

Treatment side effects

All cancer treatments can cause unwanted health issues. Such health issues are called side effects. Some side effects may be harmful to your health. Others may just be unpleasant.

Side effects depend on many factors. These factors include the treatment type, length or dose of treatment, and the person.

Ask your treatment team for a complete list of side effects of your treatments. Also, tell your treatment team about any new or worse symptoms you get. There may be ways to help you feel better. There are also ways to prevent some side effects.

Survivorship care plan

After maintenance treatment, start following your survivorship care plan. The cancer must be in remission. Survivorship care is also called follow-up care.

Your care plan should include a summary of your cancer treatment. It should also address care for your whole health and well-being. Work with your doctor to get the best plan for you.

Tests for relapse

Your care plan should include a schedule of tests for relapse. Routine testing for cancer relapse is called surveillance. If relapse occurs, early detection will allow for timely treatment.

Surveillance

A list of tests for relapse is in [Guide 4](#). These tests include a physical exam and CBC with differential. If results are good, the frequency of these tests lessens over time. For Ph-positive ALL, periodic testing for *BCR-AB1* should be done throughout survivorship.

Liver tests should be done during the first year after maintenance treatment. Some cancer treatments can cause damage to your liver. But, your liver will likely heal over time.

If results suggest a relapse, your doctor will order a bone marrow aspiration. The aspirate may be tested for cancer markers and MRD.

Guide 4. Cancer tests during survivorship

Year	What tests are needed?	How often?
Year 1	• Physical exam	Every 1 to 2 months
	• CBC with differential	Every 1 to 2 months
	• Liver function tests	Every 1 to 2 months
	• QPCR for <i>BCR-ABL1</i> gene if Ph-positive ALL	Periodic
	• Tests of cancer markers and MRD using bone marrow aspirate	Every 3 to 6 months as needed
Year 2	• Physical exam	Every 3 to 6 months
	• CBC with differential	Every 3 to 6 months
	• QPCR for <i>BCR-ABL1</i> gene if Ph-positive ALL	Periodic
	• Tests of cancer markers and MRD using bone marrow aspirate	Every 3 to 6 months as needed
Year 3 and on	• Physical exam	Every 6 to 12 months
	• CBC with differential	Every 6 to 12 months
	• QPCR for <i>BCR-ABL1</i> gene if Ph-positive ALL	Periodic
	• Tests of cancer markers and MRD using bone marrow aspirate	Every 3 to 6 months as needed for at least up to Year 5

Late side effects

Some side effects appear shortly after cancer treatment starts and quickly resolve after treatment ends. Other side effects are long-term or may appear years later. Ask your doctor to include possible late and long-term side effects in your survivorship care plan.

Side effects vary between people. Who gets which ones depends on many factors. One factor is age. Another factor is the type and intensity of the treatment.

Cancer and its treatment affects your body but also how you feel. Everyone with cancer has some level of distress. After treatment, your distress may lessen or worsen. Your doctor can help you get help for distress. Getting help should be part of your survivorship care plan.

Cancer screening

A possible late effect of some cancer treatments is a second cancer. Also, your risk for cancer increases as you age, the longer you smoke, and so forth. At follow-up visits, your doctor will examine you for signs of cancer. Doctors also use blood tests to look for signs of cancer.

If your risk for certain cancers is high enough, you may enroll in a screening program. Cancer screening is routine testing for cancer before cancer symptoms start. There is not a screening program for every type of cancer. Screening programs exist for prostate cancer (men), breast and cervical cancer (women), and colorectal cancer.

General health tests

Besides cancer tests, your survivorship care plan should address your general health. Your general health can have a big impact on your well-being. Your primary doctor or cancer doctor may provide routine health care. Make sure your survivorship care plan explains who to see for what health issues.

Disease prevention

Take steps to prevent diseases. Such steps can include getting immunization shots for the flu, herpes, and other diseases. In general, the HPV vaccine is advised for people ages 9 to 26 years of age. Dental cleaning and exams on a regular basis can prevent disease, too.

Healthy lifestyle

Start or keep a healthy lifestyle. Limit your use of alcohol. Protect yourself from the sun. Maintain a healthy weight. There is proof that healthy living can improve your treatment results.

Healthy eating is important. Eat a balanced diet. Eat the right amount of food. Drink enough fluids. A registered dietician—an expert in creating a healthy diet—can help. He or she can help you get the food you need during and after treatment.

Many cancer survivors benefit from some exercise. Exercise tones muscles, lowers stress, and improves health. Exercise programs differ between people based on their needs. Talk with your treatment team about which exercises would be best for you.

Being hooked on nicotine is one of the hardest addictions to stop. The stress of cancer may make it harder or easier to quit. Quitting is important since smoking can limit how well cancer treatment works. Talk with your treatment team about ways to quit.

Relapsed or refractory ALL

Options for relapsed or refractory ALL are listed in [Guide 5](#). More research is needed to learn how safe these treatments are among adults 65 years of age and older. The goal of treatment is to achieve remission.

The phases of treatment are like those for initial treatment. You may also receive treatment to prevent ALL from spreading to your central nervous system. If you haven't had a transplant before, you may receive an allogeneic stem cell transplant for consolidation. If you had a transplant before, you may receive a second transplant, DLI (**d**onor **l**ymphocyte **i**nfusion), or both. DLI consists of receiving lymphocytes from the same person who donated the blood stem cells for the transplant.

Ph-negative ALL

If not done before, tests of cancer markers and MRD will be needed to plan treatment. Treatment options may depend on how long the cancer was in remission. If you had a long remission, the same treatment from induction may be used.

Clinical trial

A clinical trial may be an option. Ask your treatment team if there is a clinical trial that is right for you. Doctors are still learning what the best treatment for relapsed and refractory ALL is.

Immunotherapy

Immunotherapy is a newer treatment for B-cell ALL. It includes blinatumomab, inotuzumab ozogamicin, and tisagenlecleucel. Blinatumomab and inotuzumab ozogamicin have had good results in well-designed studies.

Tisagenlecleucel may be an option if you are 25 years of age or younger. You must have refractory ALL or relapsed 2 or more times. The role of a stem cell transplant after tisagenlecleucel is unclear. Tisagenlecleucel may have good enough results that a transplant is not needed.

Chemotherapy

For T-cell ALL, nelarabine-based treatment may be an option. Nelarabine by itself may be received. Nelarabine, etoposide, and cyclophosphamide is used to treat young, fit people.

Guide 5. Treatment for relapsed or refractory ALL

What are the options for Ph-negative ALL?

- Clinical trial
- Blinatumomab
- Inotuzumab ozogamicin
- Tisagenlecleucel
- Chemotherapy
- Allogeneic stem cell transplant for consolidation

TKI = tyrosine kinase inhibitor

What are the options for Ph-positive ALL?

- Clinical trial
- TKI with or without chemotherapy or corticosteroids
- Blinatumomab if a TKI didn't work
- Inotuzumab ozogamicin
- Tisagenlecleucel
- Allogeneic stem cell transplant for consolidation

There are many regimens that can be used for either B-cell or T-cell ALL. One option is hyper-CVAD with intensified vincristine and dexamethasone. Clofarabine alone or clofarabine with cyclophosphamide and etoposide are common treatments. Other regimens include vincristine injection, MOpAD, FLAG-IDA, FLAM, other cytarabine-based treatment, and alkylator combinations. Rituximab may be added to MOpAD for CD20-positive ALL.

Ph-positive ALL

To plan treatment, tests of mutations within the *BCR-ABL1* gene should be done. Results may explain why a TKI for initial treatment stopped working. Some TKIs won't work if certain mutations are present. Your doctor will prescribe treatment based on mutations, prior treatment, your health, and other factors.

Clinical trial

A clinical trial may be an option. Ask your treatment team if there is a clinical trial that is right for you. Doctors are still learning what the best treatment for relapsed and refractory ALL is.

TKI-based treatment

Like induction, TKIs are also used to treat relapsed and refractory Ph-positive ALL. Your doctor will choose a TKI partly based on the results of mutation testing.

- Bosutinib is recommended for E255K/V, F317L/V/I/C, F359V/C/I, T315A, and Y253H mutations.
- Dasatinib is recommended for Y253H, E255K/V, or F359V/C/I mutations.
- Nilotinib is recommended for F317L/V/I/C, T315A, or V299L mutations.
- Ponatinib is recommended for T315I mutations and when no other TKI would work.

A TKI can be used alone or with chemotherapy or corticosteroids. Induction regimens may be used. If TKIs don't work, your doctor may prescribe a chemotherapy regimen that is used for Ph-negative ALL.

Immunotherapy

Immunotherapy is a newer treatment for B-cell ALL. It includes blinatumomab, inotuzumab ozogamicin, and tisagenlecleucel. Blinatumomab or inotuzumab ozogamicin may be an option if ALL worsened despite TKI-based treatment.

Tisagenlecleucel may be an option if you are 25 years of age or younger. You must have refractory ALL or relapsed 2 or more times after taking a TKI. The role of a stem cell transplant after tisagenlecleucel is unclear. Tisagenlecleucel may have good enough results that a transplant is not needed.

Review

- The goal of treatment is to cure or control ALL.
- Initial treatment for ALL has three main phases. Induction clears many, if not all, leukemic cells from bone marrow. Consolidation treats any remaining cells after induction. Maintenance treatment helps prevent a relapse.
- Options for initial treatment are mainly based on the type of ALL, your age, and your health. Joining a clinical trial may be an option. If not, chemotherapy is often used. A TKI will be added for Ph-positive ALL and rituximab may be added for CD20-positive ALL. An allogeneic stem cell transplant may be used for consolidation.
- At the end of maintenance, follow your survivorship care plan. This plan includes tests for relapse, care to prevent illness, and help for healthy living.
- Treatment for relapsed or refractory ALL can extend life for many people. It may consist of immunotherapy or regimens similar to initial treatment. If induction treatment works, you may receive an allogeneic stem cell transplant.

4

Making treatment decisions

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- 33 Questions to ask your doctors
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Having cancer is very stressful. While absorbing the fact that you have cancer, you have to learn about tests and treatments. In addition, the time you have to accept a treatment plan feels short. Parts 1 through 3 described the cancer and treatment options. Part 4 aims to help you make decisions that are in line with your beliefs, wishes, and values.

It's your choice

The role each person wants in choosing his or her treatment differs. You may feel uneasy about making treatment decisions. This may be due to a high level of stress. It may be hard to hear or know what others are saying. Stress, pain, and drugs can limit your ability to make good decisions. You may feel uneasy because you don't know much about cancer. You've never heard the words used to describe cancer, tests, or treatments. Likewise, you may think that your judgment isn't any better than your doctors'.

Letting others decide which option is best may make you feel more at ease. But, whom do you want to make the decisions? You may rely on your doctors alone to make the right decisions. However, your doctors may not tell you which option to choose if you have multiple good options. You can also have loved ones help. They can gather information, speak on your behalf, and share in decision-making with your doctors. Even if others decide which treatment you will receive, you still have to agree by signing a consent form.

On the other hand, you may want to take the lead or share in decision-making. Most patients do. In shared decision-making, you and your doctors

share information, weigh the options, and agree on a treatment plan. Your doctors know the science behind your plan but you know your concerns and goals. By working together, you are likely to get a higher quality of care and be more satisfied. You'll likely get the treatment you want, at the place you want, and by the doctors you want.

Questions to ask your doctors

You may meet with experts from different fields of medicine. Strive to have helpful talks with each person. Prepare questions before your visit and ask questions if the person isn't clear. You can also take notes and get copies of your medical records.

It may be helpful to have your spouse, partner, family member, or a friend with you at these visits. A patient advocate or navigator might also be able to come. They can help to ask questions and remember what was said. Suggested questions to ask are listed on the following pages.

What's my diagnosis and prognosis?

It's important to know that there are different types of cancer. Cancers with the same name can even greatly differ. Based on your test results, your doctor can tell you which type of cancer you have. He or she can also give a prognosis. A prognosis is a prediction of the pattern and outcome of a disease. Knowing the prognosis may affect what you decide about treatment.

1. What type of cancer do I have? From what type of cell did it form? Is this cancer common?
2. Is this a fast- or slow-growing leukemia?
3. What tests do you recommend for me?
4. Where will the tests take place? How long will the tests take and will any test hurt?
5. What if I am pregnant?
6. How do I prepare for testing?
7. Should I bring a list of my medications?
8. Should I bring someone with me?
9. How often are these tests wrong?
10. Would you give me a copy of the pathology report and other test results?
11. Who will talk with me about the next steps? When?

What are my options?

There is no single treatment practice that is best for all people. There is often more than one treatment option along with clinical trial options. Your doctor will review your test results and recommend treatment options.

1. What will happen if I do nothing?
2. Can I just carefully monitor the cancer?
3. Do you consult NCCN recommendations when considering options?
4. Are you suggesting options other than what NCCN recommends? If yes, why?
5. Do your suggested options include clinical trials? Please explain why.
6. How do my age, health, and other factors affect my options? What if I am pregnant?
7. Which option is proven to work best?
8. Which options lack scientific proof?
9. What are the benefits of each option? Does any option offer a cure or long-term cancer control? Are my chances any better for one option than another? Less time-consuming? Less expensive?
10. What are the risks of each option? What are possible complications? What are the rare and common side effects? Short-lived and long-lasting side effects? Serious or mild side effects? Other risks?
11. How do you know if treatment is working?
12. What are my options if treatment doesn't work?
13. What can be done to prevent or relieve the side effects of treatment?
14. What are my chances that the cancer will relapse?

What does each option require of me?

Many patients consider how each option will practically affect their lives. This information may be important because you have family, jobs, and other duties to take care of. You also may be concerned about getting the help you need. If you have more than one option, choosing the option that is the least taxing may be important to you:

1. Will I have to go to the hospital or elsewhere? How often? How long is each visit?
2. What do I need to think about if I will travel for treatment?
3. Do I have a choice of when to begin treatment? Can I choose the days and times of treatment?
4. How do I prepare for treatment? Do I have to stop taking any of my medicines? Are there foods I will have to avoid?
5. Should I bring someone with me when I get treated?
6. Will the treatment hurt?
7. How much will the treatment cost me? What does my insurance cover?
8. Will I miss work or school? Will I be able to drive?
9. Is home care after treatment needed? If yes, what type?
10. How soon will I be able to manage my own health?
11. When will I be able to return to my normal activities?

Deciding between options

Deciding which option is best can be hard. Doctors from different fields of medicine may have different opinions on which option is best for you. This can be very confusing. Your spouse or partner may disagree with which option you want. This can be stressful. In some cases, one option hasn't been shown to work better than another. Some ways to decide on treatment are discussed next.

2nd opinion

The time around deciding a treatment is very stressful. People with cancer often want to get treated as soon as possible. They want to make their cancer go away before it spreads farther. While cancer can't be ignored, usually there is time to think about and choose which option is best for you.

You may wish to have another doctor review your test results and suggest a treatment plan. This is called getting a 2nd opinion. You may completely trust your doctor, but a 2nd opinion about which option is best can help.

Copies of the pathology report, imaging, and other test results need to be sent to the doctor giving the 2nd opinion. Some people feel uneasy asking for copies from their doctors. However, a 2nd opinion is a normal part of cancer care.

When doctors have cancer, most will talk with more than one doctor before choosing their treatment. What's more, some health plans require a 2nd opinion. If your health plan doesn't cover the cost of a 2nd opinion, you have the choice of paying for it yourself.

If the two opinions are the same, you may feel more at peace about treatment. If the two opinions differ, think about getting a 3rd opinion. A 3rd opinion may help you decide between your options. Choosing

your cancer treatment is a very important decision. It can affect your length and quality of life.

Support groups

Support groups often include people at different stages of treatment. Some may be in the process of deciding while others may be finished with treatment. At support groups, you can ask questions and hear about the experiences of other people with ALL. If your hospital or community doesn't have support groups for people with ALL, check out the websites on the next page.

Compare benefits and downsides

Every option has benefits and downsides. Consider these when deciding which option is best for you. Talking to others can help identify benefits and downsides you haven't thought of. Scoring each factor from 0 to 10 can also help since some factors may be more important to you than others.

Websites

American Cancer Society

cancer.org/cancer/acute-lymphocytic-leukemia.html

Be The Match

bethematch.org

Children's Oncology Group

childrensoncologygroup.org/index.php/patients-and-families

The Leukemia & Lymphoma Society (LLS)

[LLS.org/InformationSpecialists](https://lls.org/InformationSpecialists)

National Cancer Institute

cancer.gov/types/leukemia

National Coalition for Cancer Survivorship

canceradvocacy.org/toolbox

NCCN for Patients®

nccn.org/patients

Stupid Cancer

stupidcancer.org

Review

- ▶ Shared decision-making is a process in which you and your doctors plan treatment together.
- ▶ Asking your doctors questions is vital to getting the information you need to make informed decisions.
- ▶ Getting a 2nd opinion, attending support groups, and comparing benefits and risks may help you decide which treatment is best for you.

Words to know

ALL

acute lymphoblastic leukemia

allogeneic stem cell transplant

A cancer treatment that replaces abnormal blood stem cells with healthy donor cells. Also called allogeneic hematopoietic cell transplant.

AML

acute myeloid leukemia

antibody

A protein in blood that helps fight off infection. Also called an immunoglobulin.

B cell

A type of a white blood cell called a lymphocyte. Also called B-lymphocyte.

BCR-ABL1

An abnormal set of cell instructions within the Philadelphia chromosome.

bone marrow

The sponge-like tissue in the center of most bones.

bone marrow aspiration

A procedure that removes a liquid bone marrow sample to test for a disease.

bone marrow biopsy

A procedure that removes bone and solid bone marrow samples to test for a disease.

CAR

chimeric antigen receptor

CBC

complete blood count

central nervous system

The brain and spinal cord.

central venous access device

A tube-shaped device placed into a vein to access the bloodstream.

chemotherapy

Cancer drugs that stop the cell life cycle so cells don't increase in number.

chromosome

The structures within cells that contain coded instructions for cell behavior (genes).

clinical trial

A type of research that assesses how well health tests or treatments work in people.

CLL

chronic lymphocytic leukemia

CML

chronic myeloid leukemia

CMV

cytomegalovirus

coagulation factors

Proteins that cause blood to clot.

complete blood count (CBC)

A lab test that measures the number of red blood cells, white blood cells, and platelets.

complete remission

No signs or symptoms of cancer.

computed tomography (CT)

A test that uses x-rays from many angles to make a picture of the insides of the body.

consolidation

A treatment phase to further reduce the number of cancer cells. Also called postremission therapy.

contrast

A dye put into your body to make clearer pictures during imaging tests.

corticosteroid

A drug used to reduce redness, swelling, and pain, but also to kill cancer cells.

CT

computed tomography

d-dimer

A protein fragment that is released when a blood clot dissolves.

deoxyribonucleic acid (DNA)

A chain of chemicals in cells that contains coded instructions for making and controlling cells. Also called the "blueprint of life."

diagnosis

An identification of an illness based on tests.

differential

A lab test of the number of white blood cells for each type.

DLI

donor lymphocyte infusion

donor lymphocyte infusion (DLI)

A cancer treatment with white blood cells from the donor of the bone marrow transplant.

DNA

deoxyribonucleic acid

echocardiogram

A test that uses sound waves to make pictures of the heart.

fertility specialist

An expert who helps people to have babies.

fibrinogen activity

A lab test of how well a protein called fibrinogen can help form a blood clot.

fusion gene

A coded instruction in a cell (gene) made from parts of two coded instructions.

gene

Coded instructions in cells for making new cells and controlling how cells behave.

HIV

human immunodeficiency virus

human leukocyte antigen (HLA)

A cell protein by which your body knows its own cells from foreign cells.

imaging

A test that makes pictures (images) of the insides of the body.

immune system

The body's natural defense against infection and disease.

immunotherapy

A treatment with drugs that may help the body find and destroy cancer cells.

induction

The first treatment that is given to greatly reduce the extent of cancer.

lumbar puncture

A procedure that removes spinal fluid with a needle.

lymph

A clear fluid containing white blood cells.

lymph node

A small, bean-shaped, disease-fighting structure.

lymph system

A network of organs and vessels that collects and transports a fluid called lymph.

lymphocyte

One of three main types of white blood cells that help protect the body from illness.

lymphoma

A cancer of white blood cells called lymphocytes that are within the lymph system.

magnetic resonance imaging (MRI)

A test that uses radio waves and powerful magnets to make pictures of the insides of the body.

maintenance

A treatment phase that is given to prolong good treatment results.

medical history

A report of all your health events and medications.

minimal residual disease (MRD)

The presence of very few cancer cells during or after treatment.

monoclonal antibody

A type of cancer drug that stops growth signals.

MRD

minimal residual disease or measurable residual disease

mutation

An abnormal change

nuclear medicine scan

An imaging test that uses radioactive substances to create images.

partial thromboplastin time

A lab test that assesses clotting factors from two of three pathways.

PET

positron emission tomography

physical exam

A study of the body by a health expert for signs of disease.

Philadelphia chromosome

An abnormal chromosome 22 that is formed when it switches parts with chromosome 9. Also called Ph chromosome.

physical exam

A study of the body by a health expert for signs of disease.

positron emission tomography (PET)

A test that uses radioactive material to see the shape and function of body parts.

prognosis

The likely course and outcome of a disease based on tests.

prothrombin time

A measure of how well all coagulation factors work together.

relapse

The return or worsening of cancer after a period of improvement.

side effect

An unhealthy or unpleasant physical or emotional response to treatment.

spleen

An organ to the left of the stomach that helps protect the body from disease.

supportive care

Health care that includes symptom relief but not cancer treatment. Also called palliative care.

T cell

A type of a white blood cell called a lymphocyte.

TKI

tyrosine kinase inhibitor

TLS

tumor lysis syndrome

translocation

The switching of parts between chromosomes.

tyrosine kinase inhibitor (TKI)

A drug that blocks the transfer of phosphate.

tumor lysis syndrome (TLS)

A health condition caused by the rapid death of many cancer cells by treatment.

ultrasound

A test that uses sound waves to take pictures of the inside of the body. Also called ultrasonography.

white blood cell

A type of blood cell that fights disease and infection.

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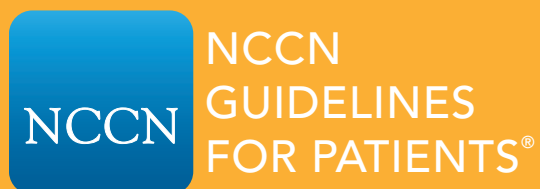
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