About Chronic Myeloid Leukemia

Overview of CML

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

- What Is Chronic Myeloid Leukemia?

Research and Statistics

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

- Key Statistics for Chronic Myeloid Leukemia
- What's New in Chronic Myeloid Leukemia Research and Treatment?

What Is Chronic Myeloid Leukemia?

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

Chronic myeloid leukemia (CML), also known as chronic myelogenous leukemia, is a type of cancer that starts in certain blood-forming cells of the bone marrow. In CML, a genetic change takes place in an early (immature) version of myeloid cells - the cells that make red blood cells, platelets, and most types of white blood cells (except lymphocytes). This change forms an abnormal gene called BCR-ABL, which turns the cell into a CML cell. The leukemia cells grow and divide, building up in the bone marrow and spilling over into the blood. In time, the cells can also settle in other parts of the body, including the spleen. CML is a fairly slow growing leukemia, but it can also change into a fast-growing acute leukemia that is hard to treat.
Most cases of CML occur in adults, but very rarely it occurs in children, too. In general, their treatment is the same as for adults.

What is leukemia?

Leukemia is a cancer that starts in the blood-forming cells of the bone marrow. When one of these cells changes and becomes a leukemia cell, it no longer matures normally. Often, it divides to make new cells faster than normal. Leukemia cells also don't die when they should. This allows them to build up in the bone marrow, crowding out normal cells. At some point, leukemia cells leave the bone marrow and spill into the bloodstream, often causing the number of white blood cells in the blood to increase. Once in the blood, leukemia cells can spread to other organs, where they can prevent other cells in the body from functioning normally.

Leukemia is different from other types of cancer that start in organs such as the lungs, colon, or breast and then spread to the bone marrow. Cancers that start elsewhere and then spread to the bone marrow are not leukemia.

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

What is a chronic leukemia?

Whether leukemia is *acute* or *chronic* depends on whether most of the abnormal cells are immature (and are more like stem cells) or mature (and are more like normal white blood cells).

In chronic leukemia, the cells can mature partly but not completely. These cells may look fairly normal, but they are not. They generally do not fight infection as well as normal white blood cells do. The leukemia cells survive longer than normal cells, and build up, crowding out normal cells in the bone marrow. Chronic leukemias can take a long time before they cause problems, and most people can live for many years. But chronic leukemias are generally harder to cure than acute leukemias.

What is a myeloid leukemia?

Whether leukemia is *myeloid* or *lymphocytic* depends on which bone marrow cells the cancer starts in.
Myeloid leukemias (also known as *myelocytic*, *myelogenous*, or *non-lymphocytic* leukemias) start in early myeloid cells -- the cells that become white blood cells (other than lymphocytes), red blood cells, or platelet-making cells (megakaryocytes).

**What are the other types of leukemia?**

There are 4 main types of leukemia, based on whether they are acute or chronic, and myeloid or lymphocytic:

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

In acute leukemias, the bone marrow cells cannot mature the way they should. These immature cells continue to reproduce and build up. Without treatment, most people with acute leukemia would only live 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. Lymphocytic leukemias (also known as lymphoid or lymphoblastic leukemia) start in the cells that become lymphocytes. Lymphomas are also cancers that start in those cells. The main difference between lymphocytic leukemias and lymphomas is that in leukemia, the cancer cell is mainly in the bone marrow and blood, while in lymphoma it tends to be in lymph nodes and other tissues.

Chronic myelomonocytic leukemia (CMML) is another chronic leukemia that starts in myeloid cells. For more information on this type of cancer, see Chronic Myelomonocytic Leukemia.

**The rest of this information is only about chronic myeloid leukemia (CML).**

- References

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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Normal Bone Marrow and Blood

Different types of leukemia are formed from different types of cells. To understand the different types of leukemia, it helps to have some basic knowledge about the blood and lymph systems. The information which follows is quite complex. It may prove helpful, but you don't need to understand all of it to learn more about your leukemia.

Bone marrow

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

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

Types of Blood cells

Red blood cells carry oxygen from the lungs to all other tissues in the body, and take carbon dioxide back to the lungs to be removed. Having too few red blood cells in the body (anemia) can make you feel tired, weak, and short of breath because your body tissues are not getting enough oxygen.

Platelets are actually cell fragments made by a type of bone marrow cell called the megakaryocyte. Platelets are important in plugging up holes in blood vessels caused by cuts or bruises. Having too few platelets (thrombocytopenia) may cause you to bleed or bruise easily.

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

Types of white blood cells

Lymphocytes are mature, infection-fighting cells that develop from lymphoblasts, a
type of blood stem cell in the bone marrow. Lymphocytes are the main cells that make up lymphoid tissue, a major part of the immune system. Lymphoid tissue is found in lymph nodes, the thymus gland, the spleen, the tonsils and adenoids, and is scattered throughout the digestive and respiratory systems and the bone marrow. The 2 major types of lymphocytes are known as B lymphocytes (B cells) and T lymphocytes (T cells). Lymphocytes help protect the body from germs. Some types of lymphocytes help regulate the immune system.

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

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

- **References**
- See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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**Key Statistics for Chronic Myeloid Leukemia**

The American Cancer Society's estimates for chronic myeloid leukemia (CML) in the United States for 2018 are:

- About 8,430 new cases will be diagnosed with CML (4,980 in men and 3,450 in
About 1,090 people will die of CML (620 men and 470 women). A little over 10% of all new cases of leukemia are chronic myeloid leukemia. About 1 person in 526 will get CML in their lifetime in the United States.

The average age at diagnosis of CML is around 64 years. Almost half of cases are diagnosed in people 65 and older. This type of leukemia mainly affects adults, and is only rarely seen in children.

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

- References
See all references for Chronic Myeloid Leukemia


Last Medical Review: February 24, 2015 Last Revised: January 4, 2018

What's New in Chronic Myeloid Leukemia Research and Treatment?

Studies of chronic myeloid leukemia (CML) are being done in labs and in clinical trials around the world.
Genetics of chronic myeloid leukemia

Scientists are making great progress in understanding how changes in a person's DNA can cause normal bone marrow cells to develop into leukemia cells. Learning about changes in the genes (regions of the DNA) involved in CML is providing insight into why these cells grow too quickly, live too long, and fail to develop into normal blood cells. The explosion of knowledge in recent years is being used to develop many new drugs.

Treatment

Combining the targeted drugs with other treatments

Imatinib and other drugs that target the BCR-ABL protein have proven to be very effective, but by themselves these drugs don’t help everyone. Studies are now in progress to see if combining these drugs with other treatments, such as chemotherapy, interferon, or cancer vaccines (see below) might be better than either one alone. One study showed that giving interferon with imatinib worked better than giving imatinib alone. The 2 drugs together had more side effects, though. It is also not clear if this combination is better than treatment with other tyrosine kinase inhibitors (TKIs), such as dasatinib and nilotinib. A study going on now is looking at combining interferon with nilotinib.

Other studies are looking at combining other drugs, such as cyclosporine or hydroxychloroquine, with a TKI.

New drugs for CML

Because researchers now know the main cause of CML (the BCR-ABL gene and its protein), they have been able to develop many new drugs that might work against it.

In some cases, CML cells develop a change in the BCR-ABL oncogene known as a T315I mutation, which makes them resistant to many of the current targeted therapies (imatinib, dasatinib, and nilotinib). Ponatinib is the only TKI that can work against T315I mutant cells. More drugs aimed at this mutation are now being tested.

Other drugs called farnesyl transferase inhibitors, such as lonafarnib and tipifarnib, seem to have some activity against CML and patients may respond when these drugs are combined with imatinib. These drugs are being studied further.
Other drugs being studied in CML include the histone deacetylase inhibitor panobinostat and the proteasome inhibitor bortezomib (Velcade).

**Cancer vaccines**

Cancer cells are different from normal cells, so it is sometimes possible to get the body's immune system to react against them. One way to do this is to use a cancer vaccine -- a substance injected into the body that boosts the immune system and causes it to attack certain cells. Several vaccines are now being studied for use against CML. For instance, in one small study, a vaccine called *CMLVAX100* was given along with imatinib and seemed to increase its effectiveness. Research into this and other vaccines is continuing.

- References
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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1-800-227-2345 or [www.cancer.org](http://www.cancer.org)
Chronic Myeloid Leukemia Causes, Risk Factors, and Prevention

Risk Factors

A risk factor is anything that affects your chance of getting a disease such as cancer. Learn more about the risk factors for chronic myeloid leukemia.

- What Are the Risk Factors for Chronic Myeloid Leukemia?
- Do We Know What Causes Chronic Myeloid Leukemia?

Prevention

There is no known way to prevent most cases of chronic myeloid leukemia. Many types of cancer can be prevented by lifestyle changes to avoid certain risk factors, but this is not true for most cases of CML. The only potentially avoidable risk factor for CML is exposure to high doses of radiation, which is seen in only a few patients.

What Are the Risk Factors for Chronic Myeloid 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 risk factors are rarely absolute. Having a risk factor, or even several risk factors, does not mean that you will get the disease. And many people who get the disease may not have had any known risk factors.

The only risk factors for CML are:
• **Radiation exposure**: Being exposed to high-dose radiation (such as being a survivor of an atomic bomb blast or nuclear reactor accident) increases the risk of getting CML
• **Age**: The risk of getting CML increases with age
• **Gender**: This disease is slightly more common in males than females, but it's not known why

There are no other proven risk factors for CML. The risk of getting CML does not seem to be affected by smoking, diet, exposure to chemicals, or infections. And CML does not run in families.

• **References**
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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**Do We Know What Causes Chronic Myeloid Leukemia?**

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 carries our genes, the instructions for how our cells function. We look like our parents because they are the source of our DNA. But our genes affect more than the way we look.

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.

Some genes control when our cells grow and divide. Certain genes that promote cell growth and division are called *oncogenes*. Others that slow down cell division or cause cells to die at the right time are called *tumor suppressor genes*. Cancers can be caused by changes in DNA (mutations) that turn on oncogenes or turn off tumor suppressor genes.
During the past few years, scientists have made great progress in understanding how certain changes in DNA can cause normal bone marrow cells to become leukemia cells. In no cancer is this better understood than in chronic myeloid leukemia (CML).

Each human cell contains 23 pairs of chromosomes. Most cases of CML start when a "swapping" of chromosomal material (DNA) occurs between chromosomes 9 and 22 during cell division. Part of chromosome 9 goes to 22 and part of 22 goes to 9. This is known as a translocation and gives rise to a chromosome 22 that is shorter than normal. This new abnormal chromosome is known as the Philadelphia chromosome. The Philadelphia chromosome is found in the leukemia cells of almost all patients with CML.

The swapping of DNA between the chromosomes leads to the formation of a new gene (an oncogene) called BCR-ABL. This gene then produces the BCR-ABL protein, which is the type of protein called a tyrosine kinase. This protein causes CML cells to grow and reproduce out of control.

In a very small number of CML patients, the leukemia cells have the BCR-ABL oncogene but not the Philadelphia chromosome. It is thought that the BCR-ABL gene must form in a different way in these people. In a very small number of people who seem to have CML, neither the Philadelphia chromosome nor the BCR-ABL oncogene can be found. They might have other, unknown oncogenes causing their disease and are not considered to truly have CML.

Sometimes people inherit DNA mutations from a parent that greatly increase their risk of getting certain types of cancer. But inherited mutations do not cause CML. DNA changes related to CML occur during the person's lifetime, rather than having been inherited before birth.

- References
See all references for Chronic Myeloid Leukemia

Can Chronic Myeloid Leukemia Be
Prevented?

There is no known way to prevent most cases of chronic myeloid leukemia (CML). Many types of cancer can be prevented by lifestyle changes to avoid certain risk factors, but this is not true for most cases of CML. The only potentially avoidable risk factor for CML is exposure to high doses of radiation, which is seen in only a few patients.

- References
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016
Chronic Myeloid Leukemia Early Detection, Diagnosis, and Staging

Detection and Diagnosis

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

- Can Chronic Myeloid Leukemia Be Found Early?
- Signs and Symptoms of Chronic Myeloid Leukemia
- How Is Chronic Myeloid Leukemia Diagnosed?

Stages and Outlook (Prognosis)

After a cancer diagnosis, staging provides important information about the extent of cancer in the body and anticipated response to treatment.

- How Is Chronic Myeloid Leukemia Staged?

Questions to Ask About CML

Here are some questions you can ask your cancer care team to help you better understand your CML diagnosis and treatment options.

- What Should You Ask Your Doctor About Chronic Myeloid Leukemia?

Can Chronic Myeloid Leukemia Be Found Early?

The American Cancer Society recommends screening tests for certain cancers in
people who have no symptoms because these cancers are easier to treat if found early. But at this time, no screening tests are routinely recommended to find chronic myeloid leukemia (CML) early.

CML can sometimes be found when routine blood tests are done for other reasons. For instance, a person's white blood cell count may be very high, even though he or she doesn't have any symptoms.

It is important to report any symptoms that could be caused by CML to the doctor right away. The symptoms of CML are discussed in [Signs and Symptoms of Chronic Myeloid Leukemia](#).

- References
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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**Signs and Symptoms of Chronic Myeloid Leukemia**

The symptoms of chronic myeloid leukemia (CML) are often vague and are more often caused by other things. They include:

- Weakness
- Fatigue
- Night sweats
- Weight loss
- Fever
- Bone pain
- An enlarged spleen (felt as a mass under the left side of the ribcage)
- Pain or a sense of "fullness" in the belly
- Feeling full after eating even a small amount of food

But these aren't just symptoms of CML. They can occur with other cancers, as well as
many non-cancerous conditions.

Some patients have bone pain or joint pain caused by leukemia cells spreading from the marrow cavity to the surface of the bone or into the joint.

**Problems caused by a shortage of blood cells**

Many of the signs and symptoms of CML occur because the leukemia cells replace the bone marrow's normal blood-making cells. As a result, people with CML do not make enough red blood cells, properly functioning white blood cells, and blood platelets.

- **Anemia** is a shortage of red blood cells. It can cause weakness, tiredness, and shortness of breath.
- **Leukopenia** is a shortage of normal white blood cells. This shortage increases the risk of infections. Although patients with leukemia may have very high white blood cell counts, the leukemia cells do not protect against infection the way normal white blood cells do.
- **Neutropenia** means that the level of normal neutrophils is low. Neutrophils, a type of white blood cell, are very important in fighting infection from bacteria. People who are neutropenic have a high risk of getting very serious bacterial infections.
- **Thrombocytopenia** is a shortage of blood platelets. It can lead to excess bruising or bleeding, with frequent or severe nosebleeds and bleeding gums. Some patients with CML actually have too many platelets (*thrombocytosis*). But since those platelets often do not function properly, these people often have problems with bleeding and bruising as well.

The most common sign of CML is an abnormal white blood cell count (blood counts are discussed further in [How is Chronic Myeloid Leukemia Diagnosed?](#)).

- **References**

  See all references for Chronic Myeloid Leukemia
How Is Chronic Myeloid Leukemia Diagnosed?

Many people with CML do not have symptoms when it is diagnosed. The leukemia is often found when their doctor orders blood tests for an unrelated health problem or during a routine checkup. Even when symptoms are present, they are often vague and non-specific.

If signs and symptoms suggest you may have leukemia, the doctor will need to check samples (specimens) of blood and bone marrow to be certain of this diagnosis. Blood is usually taken from a vein in the arm. Bone marrow is obtained through a procedure called a bone marrow aspiration and biopsy. These samples are sent to a lab, and they are looked at under a microscope for leukemia cells.

Doctors will look at the size and shape of the cells in the samples and whether they contain granules (small spots seen in some types of white blood cells). An important factor is whether the cells look mature (like normal circulating blood cells) or immature (lacking features of normal circulating blood cells). The most immature cells are called myeloblasts (often just called blasts). An important feature of a bone marrow sample is how much of it is blood-forming cells. This is known as cellularity. Normal bone marrow contains both blood-forming cells and fat cells.

When the bone marrow has more blood-forming cells than expected, it is said to be hypercellular. If too few of these cells are found, the marrow is called hypocellular.

In people with CML, the bone marrow is often hypercellular because it is full of leukemia cells. These tests may also be done after treatment to see if the leukemia is responding to treatment.

Lab tests

One or more of the following lab tests may be used to diagnose CML or to help determine how advanced the disease is.

Blood cell counts and blood cell exam

The complete blood count (CBC) is a test that measures the levels of different cells, like red blood cells, white blood cells, and platelets, in the blood. The CBC often includes a
differential (diff), which is a count of the different types of white blood cells in the blood sample. In a blood smear, some of the blood is put on a slide to see how the cells look under the microscope.

Most patients with CML have too many white blood cells with many early (immature) cells. Sometimes CML patients have low numbers of red blood cells or blood platelets. Even though these findings may suggest leukemia, this diagnosis usually needs to be confirmed by another blood test or a test of the bone marrow.

**Blood chemistry tests**

These tests measure the amount of certain chemicals in the blood, but they are not used to diagnose leukemia. They can help find liver or kidney problems caused by the spread of leukemia cells or by 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.

**Genetic tests**

Some sort of gene testing will be done to look for the Philadelphia chromosome and/or the **BCR-ABL** gene. This type of test is used to confirm the diagnosis of CML.

**Conventional cytogenetics**

This test looks at chromosomes (pieces of DNA) under a microscope to find any changes. It is also called a karyotype. Because chromosomes can best be seen when the cell is dividing, a sample of blood or bone marrow has to be grown (in the lab) so that the cells start to divide. This takes time, and is not always successful.

Normal human cells have 23 pairs of chromosomes, each of which is a certain size. The leukemia cells in many CML patients contain an abnormal chromosome known as the *Philadelphia chromosome*, which looks like a shortened version of chromosome 22. It is caused by swapping pieces (translocation) between chromosomes 9 and 22 (see *Do We Know What Causes Chronic Myeloid Leukemia?*). Finding a Philadelphia chromosome is helpful in diagnosing CML. Even when the Philadelphia chromosome can't be seen, other tests can often find the **BCR-ABL** gene.

**Fluorescent in situ hybridization**
Fluorescent in situ hybridization (FISH) is another way to look at chromosomes. This test uses special fluorescent dyes that only attach to specific genes or parts of chromosomes. In CML, FISH can be used to look for specific pieces of the **BCR-ABL** gene on chromosomes. It can be used on regular blood or bone marrow samples without culturing the cells first, so the results can come back more quickly than with conventional cytogenetics.

**Polymerase chain reaction (PCR)**

This is a super-sensitive test that can be used to look for the **BCR-ABL** oncogene in leukemia cells. It can be done on blood or bone marrow samples and can detect very small amounts of **BCR-ABL**, even when doctors can't find the Philadelphia chromosome in bone marrow cells with cytogenetic testing.

PCR can be used to help diagnose CML and is also useful after treatment to see if copies of the **BCR-ABL** gene are still there. If copies of this gene are still present it means that the leukemia is still present, even when the cells aren't detectable with a microscope.

**Imaging tests**

Imaging tests produce pictures of the inside of the body. They are not needed to diagnose CML, but sometimes may be done to look for the cause of symptoms or to see if the spleen or liver are enlarged.

**Computed tomography scan**

A [CT scan](https://www.mayoclinic.org/tests-procedures/computed-tomography) can help tell if any lymph nodes or organs in your body are enlarged. It isn't usually needed to diagnose CML, but it may be done if your doctor suspects the leukemia is growing in an organ, like your spleen.

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 remain 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 sample is then removed to be looked at under a microscope. This is rarely needed in CML.

**Magnetic resonance imaging scan**
Magnetic resonance imaging (MRI) scans are very helpful in looking at the brain and spinal cord.

**Ultrasound**

Ultrasound can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside your abdomen such as the kidneys, liver, and spleen. This is an easy test to have, and it doesn't use radiation. For most scans you simply lie on a table, and a technician moves the transducer over the part of your body being looked at.

- References

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

How Is Chronic Myeloid Leukemia Staged?

Most types of cancer are assigned a stage based on the size of the tumor and the extent of cancer spread. Stages can be helpful in predicting prognosis (outlook).

But because chronic myeloid leukemia (CML) is a disease of the bone marrow, it isn't staged like most cancers. The outlook for someone with CML depends on other information, such as the phase of the disease, as well as factors like the age of the patient, blood counts, and if the spleen is enlarged.

Phases of chronic myeloid leukemia

CML is classified into 3 groups that help predict outlook. Doctors call these groups *phases* instead of stages. The phases are based mainly on the number of immature white blood cells — myeloblasts (blasts) — that are seen in the blood or bone marrow. Different groups of experts have suggested slightly different cutoffs to define the phases, but a common system (proposed by the World Health Organization) is
described below. Not all doctors may agree with or follow these cutoff points for the different phases. If you have questions about what phase your CML is in, be sure to have your doctor explain it to you.

**Chronic phase**

Patients in this phase typically have less than 10% blasts in their blood or bone marrow samples. These patients usually have fairly mild symptoms (if any) and usually respond to standard treatments. Most patients are diagnosed in the chronic phase.

**Accelerated phase**

Patients are considered to be in accelerated phase if any of the following are true:

- The bone marrow or blood samples have more than 10% but fewer than 20% blasts
- High blood basophil count (basophils making up at least 20% of the white blood cells)
- High white blood cell counts that do not go down with treatment
- Very high or very low platelet counts that are not caused by treatment
- New chromosome changes in the leukemia cells

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

**Blast phase (also called acute phase or blast crisis)**

Bone marrow and/or blood samples from a patient in this phase have more than 20% blasts. The blast cells often spread to tissues and organs beyond the bone marrow. These patients often have fever, poor appetite, and weight loss. In this phase, the CML acts much like an aggressive acute leukemia.

**Prognostic factors for chronic myeloid leukemia**

Along with the phase of CML, there are other factors that may help predict the outlook for survival. These factors are sometimes helpful when choosing treatment. Factors that tend to be linked with shorter survival time are called *adverse prognostic factors*.

**Adverse prognostic factors:**
• Accelerated phase or blast phase
• Enlarged spleen
• Areas of bone damage from growth of leukemia
• Increased number of basophils and eosinophils (certain types of granulocytes) in blood samples
• Very high or very low platelet counts
• Age 60 years or older
• Multiple chromosome changes in the CML cells

Many of these factors are taken into account in the Sokal system, which develops a score used to help predict prognosis. This system considers the person's age, the percentage of blasts in the blood, the size of the spleen, and the number of platelets. These factors are used to divide patients into low-, intermediate-, or high-risk groups. Another system, called the Euro score, includes the above factors, as well as the number of blood basophils and eosinophils. Having more of these cells indicates a poorer outlook.

The Sokal and Euro models were helpful in the past, before the newer, more effective drugs for CML were developed. It's not clear how helpful they are at this time in predicting a person's outlook. Targeted therapy drugs like imatinib (Gleevec®) have changed the treatment of CML dramatically over the last several years. These models haven't been tested in people who are being treated with these drugs.

**Survival Rates for Chronic Myeloid Leukemia**

Highly effective drugs to treat most cases of chronic myeloid leukemia (CML) first became available in 2001. There is no accurate information yet on how long patients treated with these drugs may live. All that is known is that most patients who have been treated with these drugs, starting in 2001 (or even before), are still alive.

One large study of CML patients treated with imatinib (Gleevec®) found that about 90% of them were still alive 5 years after starting treatment. Most of these patients had normal white blood cells and chromosome studies after 5 years on the drug.

• References

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016
What Should You Ask Your Doctor About Chronic Myeloid 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 phase is my chronic myeloid leukemia in?
- What are my treatment choices?
- Which treatment do you recommend, and why?
- How long will treatment last and what will it be like?
- How often will you test my blood or bone marrow to see how my therapy is working?
- What side effects are there to the treatments that you recommend?
- What can I do to be ready for treatment?
- Should I consider a stem cell transplant at this time?
- What are the chances that my leukemia will come back once I am in remission?
- What type of follow-up will I need after treatment?

Be sure to write down any questions that occur to you that are not on this list. For instance, you might want information about recovery times so that you can plan your work schedule. Or you may want to ask about second opinions or qualifying for clinical trials.

Taking another person and/or a tape recorder to your appointments can be helpful. Getting copies of your medical records, including pathology and radiology reports, may be useful in case you wish to seek a second opinion at a later time.

- References
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016
Treating Chronic Myeloid Leukemia

General information

This section starts with general comments about types of treatments used for chronic myeloid leukemia (CML). This is followed by a discussion of treatment options based on the phase of CML.

Targeted therapy drugs are the main treatment for CML. Some patients might also need other treatments, such as:

- Interferon
- Chemotherapy
- Radiation therapy
- Surgery
- Stem cell transplant

For information on common treatment plans, see Treating Chronic Myeloid Leukemia by Phase.

Thinking about taking part in a clinical trial

Clinical trials are carefully controlled research studies that are done to get a closer look at promising new treatments or procedures. Clinical trials are one way to get state-of-the-art cancer treatment. In some cases they may be the only way to get access to newer treatments. They are also the best way for doctors to learn better methods to treat cancer. Still, they are not right for everyone.

If you would like to learn more about clinical trials that might be right for you, start by asking your doctor if your clinic or hospital conducts clinical trials. See Clinical Trials to learn more.
Considering complementary and alternative methods

You may hear about alternative or complementary methods that your doctor hasn’t mentioned to treat your cancer or relieve symptoms. These methods can include vitamins, herbs, and special diets, or other methods such as acupuncture or massage, to name a few.

Complementary methods refer to treatments that are used along with your regular medical care. Alternative treatments are used instead of a doctor’s medical treatment. Although some of these methods might be helpful in relieving symptoms or helping you feel better, many have not been proven to work. Some might even be dangerous.

Be sure to talk to your cancer care team about any method you are thinking about using. They can help you learn what is known (or not known) about the method, which can help you make an informed decision. See the Complementary and Alternative Medicine section to learn more.

Help getting through cancer treatment

Your cancer care team will be your first source of information and support, but there are other resources for help when you need it. Hospital- or clinic-based support services are an important part of your care. These might include nursing or social work services, financial aid, nutritional advice, rehab, or spiritual help.

The American Cancer Society also has programs and services – including rides to treatment, lodging, support groups, and more – to help you get through treatment. Call our National Cancer Information Center at 1-800-227-2345 and speak with one of our trained specialists.

The treatment information given here is not official policy of the American Cancer 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.

Targeted Therapies for Chronic Myeloid Leukemia
Chronic myeloid leukemia (CML) cells contain an abnormal gene, BCR-ABL, that isn't found in normal cells. This gene makes a protein, BCR-ABL, which causes CML cells to grow and reproduce out of control. BCR-ABL is a type of protein known as a tyrosine kinase. Drugs known as tyrosine kinase inhibitors (TKIs) that target BCR-ABL are the standard treatment for CML. These include:

- Imatinib (Gleevec)
- Dasatinib (Sprycel)
- Nilotinib (Tasigna)
- Bosutinib (Bosulif)
- Ponatinib (Iclusig)

These drugs seem to work best on CML that is still in the chronic phase, but they also can help patients with more advanced disease. In most people, the TKIs don't seem to make the leukemia go away forever, so these drugs need to be taken indefinitely. But for some people who have very good, long-lasting responses to treatment, it might be possible to stop taking these drugs, or at least lower the dose (see Treating Chronic Myeloid Leukemia by Phase).

All of these drugs can have serious interactions with some other drugs, over-the-counter supplements, and even certain foods (such as grapefruit and pomegranate). Be sure that your doctor always has an up-to-date list of any medicines you are taking, including over-the-counter medicines, vitamins, and herbal supplements. You also need to check with your doctor before starting any new medicine, to be sure it is safe.

It's also important to understand that all of the TKIs can harm a fetus if taken during pregnancy.

**Imatinib**

Imatinib (Gleevec) was the first drug to specifically target the BCR-ABL tyrosine kinase protein, and it quickly became the standard treatment for CML patients. Because it was the first TKI, imatinib is known as a first-generation tyrosine kinase inhibitor.

Almost all CML patients respond to treatment with imatinib, and most of these responses seem to last for many years.

Imatinib is taken by mouth as a pill with food, usually once a day.

Common side effects can include diarrhea, nausea, muscle pain, and fatigue. These are generally mild. About 30% of people taking the drug have itchy skin rashes. Most of these symptoms can be treated effectively, if needed.
Another common side effect is fluid buildup around the eyes, feet, or abdomen. In rare cases the fluid may collect in the lungs or around the heart, which can cause trouble breathing. Some studies have suggested that some of this fluid buildup may be caused by effects of the drug on the heart, though this is rare. It's not yet clear how serious this is or if it might go away if treatment is stopped. If you are taking this drug, tell your doctor right away if you notice sudden weight gain or fluid buildup anywhere in the body or have trouble breathing.

Another possible side effect is a drop in a person's white blood cell and platelet counts. When this happens at the beginning of treatment, it might be because the blood-forming cells that are making these are part of the malignant process. If this is the case, normal blood-forming cells take over and the blood counts will begin to rise to normal over time.

Your doctor might tell you to stop taking the drug for a short period if your blood counts get too low. This can also happen later on in treatment. In the past, low red blood cell counts were treated with a red cell growth factor, such as epoetin (Procrit) or darbepoetin (Aranesp), but these drugs are used less often now. Instead, your doctor may lower the dose of imatinib to see if your blood counts improve.

In some patients, imatinib eventually seems to stop working. This is known as imatinib resistance. Resistance to imatinib seems to be caused by changes in the genes of the CML cells. Sometimes this resistance can be overcome by increasing the dose of imatinib, but some patients need to change to a different drug, such as one of the other TKIs described further on.

**Dasatinib**

Dasatinib (Sprycel) is another TKI that targets the BCR-ABL protein. Because it was developed after imatinib, it is called a second-generation TKI. Like imatinib, this drug is a pill taken by mouth.

Dasatinib can be used as the first treatment for CML, but it can also be helpful for patients who can’t take imatinib because of side effects or because imatinib isn’t working.

When it was first approved, dasatinib was a pill taken twice a day, but more often now a larger dose is taken once a day.

The possible side effects of dasatinib seem to be similar to those of imatinib, including fluid buildup, lowered blood cell counts, nausea, diarrhea, and skin rashes. A serious side effect that can occur with this drug is fluid buildup around the lung (called a pleural
effusion). This side effect is more common in patients taking this drug twice a day. The fluid can be drained off with a needle, but it can build up again, and may require the dose of dasatinib to be decreased.

**Nilotinib**

Nilotinib (Tasigna) is another second-generation TKI that targets the BCR-ABL protein. Like dasatinib, this drug can be used as a first treatment for CML, as well as for use in people who can’t take imatinib or whose CML no longer responds to it.

**Side effects** of nilotinib seem to be mild, but can include fluid buildup, lowered blood cell counts, nausea, diarrhea, and some lab test abnormalities. It can cause high blood sugar and pancreatitis, although this is rare.

This drug can also affect the rhythm of the heart, causing a condition called *prolonged QT syndrome*. This usually doesn't cause any symptoms, but can be serious or even fatal. This is why patients should have an electrocardiogram (EKG) before starting nilotinib and then again while being treated. This heart rhythm problem can sometimes be caused by nilotinib interacting with other drugs or supplements, so it's especially important to be sure that your cancer doctor knows about any medicines you take, including over-the-counter medicines and supplements. You also need to check with your doctor before starting any new medicine, to be sure it is safe.

**Bosutinib**

Bosutinib (Bosulif) is another TKI that targets the BCR-ABL protein. It can be used as the first treatment for CML, although more often it’s used if another TKI is no longer working.

Common **side effects** are usually mild and include diarrhea, nausea, vomiting, abdominal pain, rash, fever, fatigue, and low blood cell counts (including low platelet counts, low red blood cell counts, and low white blood cell counts). Less often, this drug can also cause problems with fluid retention, liver damage, and severe allergic reaction. Your doctor will check your blood test results regularly to watch for problems with your liver and low blood counts.

**Ponatinib**

Ponatinib (Iclusig) is a newer TKI targeting the BCR-ABL protein. Because of risks of some serious side effects, this drug is only used to treat patients with CML if all of the
other TKIs don’t work or if their leukemia cells have a certain gene change called the 
*T315I mutation*. This mutation occurs in the leukemia cells of some CML patients who are treated with a TKI, and it prevents other TKIs from working. Ponatinib is the first TKI to work against CML cells that have this mutation.

This drug is a pill taken once a day.

Most **side effects** are mild and can include abdominal (belly) pain, headache, rash or other skin problems, and fatigue.

High blood pressure is also fairly common, and it may need to be treated with a blood pressure drug.

There is also a risk of serious blood clots that can lead to heart attacks and strokes, or block arteries and veins in the arms and legs. Rarely, blood clots in patients taking this drug have cut off circulation, and lead to an arm or leg needing to amputated (cut off). Surgery or some other procedure may be needed to treat these blood clots. The risk of serious blood clots is higher in older patients, those with certain risk factors, such as high blood pressure, high cholesterol, or diabetes, and those who have already had a heart attack, stroke, or poor circulation.

Less often, this drug can also weaken the heart muscle, leading to a condition known as congestive heart failure. It can also cause liver problems, including liver failure, as well as pancreatitis (inflammation of the pancreas, which can lead to severe belly pain, nausea, and vomiting).

For general information about targeted therapy, see [Targeted Therapy](#).

- **References**

[See all references for Chronic Myeloid Leukemia](#)

Last Medical Review: February 24, 2015 Last Revised: December 27, 2017

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**Interferon Therapy for Chronic Myeloid Leukemia**

Interferons are a family of substances naturally made by our immune system.
Interferon-alpha is the type most often used in treating chronic myeloid leukemia (CML). This substance reduces the growth and division of leukemia cells. Interferon was once considered the best treatment for CML, but imatinib (Gleevec®) was shown to be better. Now, the tyrosine kinase inhibitors are the mainstay of treatment and interferon is rarely used.

To treat CML, this drug is most often given as a daily injection under the skin. It may also be injected into a muscle or vein. To treat CML, interferon is given for several years.

Interferon can cause significant side effects. These include "flu-like" symptoms like muscle aches, bone pain, fever, headaches, fatigue, nausea, and vomiting. Patients taking this drug may have problems thinking and concentrating. Interferon can also lower blood cell counts. These effects continue as long as the drug is used, but can become easier to tolerate over time. They do improve after the drug is stopped. Still, some patients find it hard to deal with these side effects every day and may need to stop treatment because of them.

For more information about drugs that use the immune system, see Immunotherapy.

- References
  See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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Chemotherapy for Chronic Myeloid Leukemia

Chemotherapy (chemo) is the use of anti-cancer drugs that are injected into a vein or taken by mouth. These drugs enter the bloodstream and reach all areas of the body, making this type of treatment useful for cancers such as leukemia that spread throughout the body. Any drug used to treat cancer (including tyrosine kinase inhibitors or TKIs) can be considered chemo, but here chemo is used to mean treatment with conventional cytotoxic drugs that mainly kill cells that are growing and dividing.
Chemo was once one of the main treatments for patients with chronic myeloid leukemia (CML), but it is used much less often now that TKIs like imatinib (Gleevec®) are available. Now, chemo may be used to treat CML when the TKIs have stopped working. It is also used as part of the treatment during a stem cell transplant.

The chemo drug hydroxyurea (Hydrea®) is taken as a pill, and can help lower very high white blood cell counts and shrink an enlarged spleen. Other drugs sometimes used include cytarabine (Ara-C), busulfan, cyclophosphamide (Cytoxan®), and vincristine (Oncovin®).

Omacetaxine (Synribo®) is a chemo drug that was approved to treat CML that is resistant to some of the TKIs now in use. It can help some patients whose CML has developed the T315I mutation that keeps most TKIs from working (discussed in the section about targeted therapy).

**Side effects of chemotherapy**

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.

Possible side effects depend on the type and dose of drugs given and the length of time they are taken. Some common side effects of chemotherapy include:

- Hair loss
- Mouth sores
- Loss of appetite
- Nausea and vomiting
- Low white blood cell counts (*leukopenia*), which increases the risk of serious infection
- Low blood platelet counts (*thrombocytopenia*), which can lead to easy bruising or bleeding
- Low red blood cell counts (*anemia*), which can lead to feeling tired and weak

Still, different drugs can have different side effects. For example, vincristine can cause nerve damage (*neuropathy*) leading to numbness, tingling, or even pain or weakness in the hands or feet. Lung damage from busulfan is rare, but can be severe. Before
starting treatment, speak with your health care team about the drugs you will receive and their possible side effects. Most side effects last a short time and go away once treatment is finished, but some can be permanent.

While getting treatment, be sure to tell your cancer care team about any side effects you have because there may be ways to lessen them. For example, drugs can be given to prevent or reduce nausea and vomiting.

If your white blood cell count gets very low after treatment with chemo, drugs known as growth factors, G-CSF (Neupogen®) and GM-CSF (Leukine®), for example, may be given to increase the white blood cell counts and reduce the chance of infection.

For information on infections and how to avoid them, see Infections in People With Cancer.

If your platelet counts are low, you may be given drugs or platelet transfusions to help protect against bleeding. Likewise, if low red blood cell counts are causing problems (like shortness of breath and/or weakness), you may be treated with red blood cell transfusions.

More information about chemotherapy can be found in the chemotherapy section of our website.

**References**

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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**Radiation Therapy for Chronic Myeloid Leukemia**

Radiation therapy is treatment with high-energy rays or particles to destroy cancer cells. Radiation therapy is usually not part of the main treatment for patients with chronic myeloid leukemia (CML), but it is used in certain situations.
Patients may have symptoms if swollen internal organs (such as an enlarged spleen) press on other organs. For instance, pressure against the stomach may affect appetite. If these symptoms are not helped by chemotherapy, radiation therapy to shrink the spleen may be an option.

Radiation therapy can also be useful in treating pain from bone damage caused by the growth of leukemia cells within the bone marrow.

Radiation therapy is sometimes given in low doses to the whole body, just before a stem cell transplant (see Stem Cell Transplant for Chronic Myeloid Leukemia).

The main short-term sideeffects of radiation therapy depend in part on what area of the body is treated.

- Fatigue (tiredness) is a common side effect (no matter what part of the body is treated)
- Skin changes can occur in the treated area which range from mild redness to blistering and peeling.
- If the radiation is aimed at the areas of the head or neck, the inside lining of your mouth and throat may become red and irritated - this is called mucositis.
- Radiation to the belly or pelvis can cause nausea and vomiting and/or diarrhea.
- If large parts of the body are treated with radiation, the bone marrow may be affected, leading to low blood counts.

More information on radiation therapy can be found in the radiation section of our website.

- References
See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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Surgery for Chronic Myeloid Leukemia

Leukemia cells spread widely throughout the bone marrow and other organs, so surgery
cannot be used to cure this type of cancer. Surgery rarely has any role even in diagnosing chronic myeloid leukemia (CML), since a blood test or bone marrow aspirate and biopsy are usually all that is needed.

If leukemia spreads to the spleen, that organ can become large enough to compress nearby organs and cause symptoms. If chemotherapy or radiation does not help shrink the spleen, it may be removed with surgery. This operation, called a splenectomy, is meant to improve the symptoms of an enlarged spleen — it has no role in curing CML.

Splenectomy may also improve blood cell counts and lower the need for blood product transfusions. One of the spleen's normal functions is to remove worn-out blood cells from the bloodstream. If leukemia or other diseases cause the spleen to become too large, it may become too active in removing blood cells, leading to a shortage of red blood cells or platelets. Taking out the spleen may improve red blood cell and platelet counts in some patients.

Most people have no problem living without a spleen. The risk for certain bacterial infections is increased, which is why doctors often recommend certain vaccines be given before the spleen is removed.

- References
  See all references for Chronic Myeloid Leukemia

Stem Cell Transplant for Chronic Myeloid Leukemia

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 better at killing leukemia cells, they are not given because the severe damage to bone marrow cells would cause lethal shortages of blood cells.

For a stem cell transplant (SCT), high doses of chemotherapy are given to kill the
leukemia cells. Sometimes the whole body also is given a low dose of radiation. This treatment kills the leukemia cells, but also damages the normal bone marrow cells. Then after these treatments, 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 (called a peripheral blood stem cell transplant, or PBSCT) or from the bone marrow (called a bone marrow transplant, or BMT). Bone marrow transplant was more common in the past, but it has largely been replaced by PBSCT.

The 2 main types of stem cell transplants are allogeneic and autologous.

For an **autologous transplant**, the patient’s own stem cells are collected from the blood or bone marrow and then given back after treatment. The problem with that is that leukemia cells may be collected with the stem cells.

In an **allogeneic transplant**, the stem cells come from someone else (a donor). To lower the chance of complications, the donor needs to “match” the patient in terms of tissue type. Often, a close relative, such as a brother or sister is a good match. Less often, a matched unrelated donor may be found.

Because collecting the patient’s stem cells can also collect leukemia cells, allogeneic transplants are the main type of transplant used to treat patients with chronic myeloid leukemia (CML). Allogeneic stem cell transplant is the only known cure for CML. Still, this type of transplant can cause severe or even life-threatening complications and side effects, and it is often not be a good option in people who are older or have other health problems.

Before modern targeted therapy drugs like imatinib (Gleevec), SCT was commonly used to treat CML. The drugs that were available at that time did not work very well, and fewer than half of patients survived more than 5 years after diagnosis. Now, targeted drugs like imatinib are the standard treatment, and transplants are being used less often. Still, because allogeneic SCT offers the only proven chance to cure CML, doctors may still recommend a transplant for younger patients, particularly children. It is more likely to be considered for those with an available matched donor, like a well-matched brother or sister. Transplant may also be recommended if the CML is not responding well to the targeted drugs.


- **References**
How Do You Know If Treatment for Chronic Myeloid Leukemia Is Working?

If you have chronic myeloid leukemia (CML) and are being treated with targeted drugs, your doctor will check your blood counts, examine you, and will order other tests like bone marrow biopsy and PCR (of blood and/or bone marrow). Doctors look for different kinds of responses to treatment:

**Hematologic response** is based on the complete blood count, and usually happens within the first 3 months of treatment.

- When blood cell counts return to normal, there are no immature cells seen in the blood, and the spleen has returned to normal size it is called a *complete hematologic response* (or CHR).
- A *partial hematologic response* means that there has been some improvement, but there are still signs or symptoms of CML. The white blood cell count is less than half of what it was before treatment, the platelet count is still high but is may be less than half what it was before treatment, and/or the spleen is still enlarged (but it has shrunk in size).

**Cytogenetic response** is based on testing of the bone marrow with either cytogenetics or FISH (these were discussed in *How Is Chronic Myeloid Leukemia Diagnosed?*). This takes longer to occur than the hematologic response.

- A *complete cytogenetic response* (CCyR) occurs when no cells with the Philadelphia chromosome can be found in the bone marrow.
- A *partial cytogenetic response* (PCyR) occurs when 1% to 34% of cells still have the Philadelphia chromosome.
- A *major cytogenetic response* (MCyR) includes both complete and partial responses, and means less than 35% of cells have the Philadelphia chromosome.
A minor cytogenetic response occurs when 35% to 90% of cells still have the Philadelphia chromosome.

**Molecular response** is based on the results of the PCR test on either the blood or bone marrow.

- A *complete molecular response* (CMR) means that the PCR test does not find the *BCR-ABL* gene in the patient's blood.
- A *major molecular response* (MMR) means that the amount of *BCR-ABL* gene in the blood is 1/1000th (or less) of what is expected in someone with untreated CML.

**References**

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016

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**Treating Chronic Myeloid Leukemia by Phase**

Treatment options for people with chronic myeloid leukemia (CML) depend on the phase of their disease (chronic, accelerated, or blast phase), their age, other prognostic factors, and the availability of a stem cell donor with matching tissue type.

**Chronic phase**

The standard treatment for chronic phase CML is a *tyrosine kinase inhibitor* (TKI) such as imatinib (Gleevec), nilotinib (Tasigna), dasatinib (Sprycel), or bosutinib (Bosulif). If the first drug stops working (or it never really worked well at all), the dose may be increased or one of the other TKIs might be tried. Ponatinib (Iclusig) is an option after all of the other TKIs have been tried or if the leukemia cells later develop the T315I mutation.

Switching to another TKI is also an option if a person can't take the first drug because of side effects.
Some people in chronic phase may be treated with an allogeneic stem cell transplant (SCT). This treatment is discussed in detail in Stem Cell Transplant for Chronic Myeloid Leukemia.

**Monitoring treatment results**

Monitoring the patient to see how they respond to treatment is very important. Blood counts are checked, and either the blood is checked with a polymerase chain reaction (PCR) test to measure the amount of the *BCR-ABL* gene or the bone marrow is checked to see if the Philadelphia chromosome is there. Blood counts may be checked more often, but testing for the *BCR-ABL* gene or the Philadelphia chromosome is usually done about 3 months after a TKI is started, and then every 3 to 6 months after that. If the results show that treatment is working well, the patient stays on their current drug. If the results show that treatment isn’t working well, a new drug or treatment may be needed.

If the CML is responding well to treatment, 3 months after starting treatment, the patient should have:

- A complete hematologic response (CHR), and
- Some type of cytogenetic response, and/or
- A reduction of the number of copies of *BCR-ABL* on the PCR test by 90% or more

If treatment is working well, 18 months after starting treatment, the patient should have:

- A complete hematologic response (CHR), and
- A complete cytogenetic response (CCyR), and/or
- A major molecular response (MMR)

(For definitions of the different response types, see How Do You Know If Treatment for Chronic Myeloid Leukemia Is Working?)

**How often is treatment successful?**

Up to about 70% of people have a complete cytogenetic response (CCyR) within 1 year of starting imatinib, and the rate of CCyR is even higher with other TKIs. After a year, even more patients will have had a CCyR. Many of these patients also have a complete molecular response (CMR).

But even in patients in whom the *BCR-ABL* gene can no longer be found while on treatment, it’s often not clear if they are cured, so most people need to stay on a TKI
indefinitely. In patients who have a deep, long-lasting response to treatment (usually for at least 2 or 3 years), some doctors might suggest stopping the drug for a time and closely monitoring with blood tests to see if the CML returns. In studies so far, typically about half of these patients can stop treatment without the CML returning. Another option might be lowering the dose of the TKI, which can reduce side effects.

If the CML does return after stopping or lowering the dose of the TKI, it typically responds well if the original treatment is restarted.

**If the first treatment doesn’t work**

If the leukemia doesn’t respond well to the first treatment, there are several options.

- Increasing the dose of the drug. This helps some people, although the higher dose often has worse side effects.
- Switching to another TKI, for example from imatinib to dasatinib, nilotinib, or bosutinib. The doctor may check the CML cells for genetic changes (mutations) to help decide what drug would be best.
- **Interferon** or **chemotherapy** (chemo) may be tried for those who can’t take these drugs or those for whom they are not working,
- **Stem cell transplant** may be an option, especially for younger people who have a donor with a matching tissue type.

**Treating CML after a stem cell transplant**

Some people who have a stem cell transplant may not get a complete response. If they do not have graft-versus-host disease (GVHD), doctors may try to get their new immune system to fight the leukemia. One way to do this is by slowly lowering the doses or stopping the immune suppressing drugs they are taking. This is done very carefully in order to have an anti-leukemia effect without getting too much GVHD. Patients are watched closely during this time. Another approach that helps some patients is an infusion of lymphocytes taken from the person who donated the stem cells for the transplant (called donor lymphocyte infusion). This can induce an immune reaction against the leukemia. Interferon may also be helpful.

In patients who do have GVHD after a stem cell transplant, boosting the immune system further is not likely to help. These patients are often treated with a TKI like imatinib.
**Accelerated phase**

When CML is in accelerated phase, leukemia cells begin to build up in the body more quickly, causing symptoms. The leukemia cells often acquire new gene mutations, which help them grow and might make treatments less effective.

The treatment options for accelerated phase CML depend on what treatments the patient has already had. In general, the options are similar to those for patients with chronic phase CML, but patients with accelerated phase CML are less likely to have a long-term response to any treatment.

If the patient hasn’t had any treatment, a **TKI** will be used. Imatinib (often at higher doses than used for chronic phase CML) is one option for most people. Most patients in this phase can respond to treatment with imatinib, but the responses do not seem to last as long as they do in patients in the chronic phase. Still, about half these patients are still alive after 4 years. The newer drugs like dasatinib and nilotinib are often used in this phase, and other drugs are under study.

If the patient is already getting imatinib, the dose may be increased. Another option is to switch to one of the other TKIs (dasatinib, nilotinib, or bosutinib). Sometimes the CML cells are tested to see if they have genetic changes (mutations) that may mean that a certain TKI is more or less likely to work (see the section “CML with the T315I mutation”). In CML without that mutation, ponatinib is an option after all of the other TKIs have been tried.

**Interferon** is another option, but it is also much less effective in this phase than in the chronic phase. About 20% of patients have some response to chemo, but these responses are usually shorter than 6 months.

An **allogeneic stem cell transplant** may be the best option for most patients who are young enough to be eligible. About 20% to 40% of patients with accelerated phase CML are alive several years after a stem cell transplant. Most doctors prefer that the leukemia be controlled, preferably in remission, before beginning the transplant procedure. To achieve this, **chemo** will often be used.

In some cases, an autologous SCT may be an option to try to get the CML back into the chronic phase, but it’s very unlikely to result in a cure.

**Blast phase**
In the blast phase of CML, the leukemia cells become more abnormal. The disease acts like an acute leukemia, with blood counts getting higher and symptoms appearing or becoming more severe.

For people with blast phase CML who haven't been treated before, high-dose imatinib may be helpful, although it works in a smaller number of people and for shorter lengths of time than when used earlier in the course of the disease. Newer TKIs, such as dasatinib, nilotinib, and bosutinib, seem to be better in this phase, particularly if they hadn't been used earlier. Ponatinib may also be used, but only after all of the other TKIs have been tried. Patients who respond to these drugs may still want to consider having a stem cell transplant, if possible.

Most often, the leukemia cells in this phase act like cells of acute myeloid leukemia (AML), but they are often resistant to the chemo drugs normally used to treat AML. Standard chemo for AML will bring about a remission in about 1 out of 5 patients, but this is usually short-lived. If remission does occur, it may be a chance to consider some type of stem cell transplant.

A smaller number of patients have blast cells that act like cells of acute lymphoblastic leukemia (ALL). These cells are more sensitive to chemo drugs. Remissions can be induced in about half of these patients with drugs such as vincristine, prednisone, and doxorubicin, along with imatinib, if that hasn't been given yet. Like patients with ALL, these patients are at risk for having leukemia cells in the fluid that surrounds the brain and spinal cord, so they often get chemo (cytarabine or methotrexate) infused directly into that fluid (like during a spinal tap). Radiation therapy to the brain is another option but is used less often. For more information, see Acute Lymphocytic Leukemia.

Allogeneic SCT is less successful for blast phase CML than for earlier phases, and the long-term survival rate is less than 10%. Still, it is the only known option that may cure the disease. It is more likely to be effective if the CML can be brought back to the chronic phase before the transplant.

Because most patients with blast phase CML can't be cured, palliative treatment (intended to relieve symptoms rather than cure the disease) is important. Radiation therapy can help shrink an enlarged spleen or reduce pain from areas of bone damaged by leukemia. Chemo (usually with drugs such as hydroxyurea) may relieve some symptoms for a time.

Clinical trials of new combinations of chemo, targeted agents, and biologic therapies are important options.
CML with the T315I mutation

As was mentioned in the section about targeted therapy, in some patients on TKI treatment, the cancer cells develop a gene change called the T315I mutation that keeps most of the TKIs from working. If your CML stops responding to treatment with a TKI, another one may be tried. Your doctor may also check to see if the cancer cells have developed the T315I mutation. If they have, you may be switched to ponatinib, which is the only TKI that works against CML with this mutation. If this doesn’t work or you can’t take it because of side effects, you may be started on chemotherapy (chemo). Omacetaxine (Synribo) is a newer chemo drug that has been shown to help sometimes in this situation, but other chemo drugs may help as well.

• References
See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: December 27, 2017

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After Chronic Myeloid Leukemia Treatment

Living as a CML Survivor

For many people, cancer treatment often raises questions about next steps as a survivor.

- What Happens After Treatment for Chronic Myeloid Leukemia?
- Lifestyle Changes After Treatment for Chronic Myeloid Leukemia
- How Does Having Chronic Myeloid Leukemia Affect Your Emotional Health?

Cancer Concerns After Treatment

Treatment may remove or destroy the cancer, but it is very common to have questions about cancer coming back or treatment no longer working.

- Can I Get Another Cancer After Getting Chronic Myeloid Leukemia?
- If Treatment for Chronic Myeloid Leukemia Stops Working

What Happens After Treatment for Chronic Myeloid Leukemia?

For a few people with chronic myeloid leukemia (CML), treatment may remove or destroy the cancer. Completing treatment can be both stressful and exciting. You may be relieved to finish treatment, but find it hard not to worry about cancer coming back. (When cancer comes back after treatment, it is called recurrence.) This is a very common concern in people who have had cancer.

It may take a while before your fears lessen. But it may help to know that many cancer
survivors have learned to live with this uncertainty and are leading full lives. See Understanding Recurrence for more detailed information.

For most patients with CML, treatment doesn't end and they stay on a tyrosine kinase inhibitor (TKI) like imatinib indefinitely. Often, the TKIs keep the CML in check, but they don't seem to cure this disease. Being on long-term treatment can be difficult and very stressful. It has its own type of uncertainty. See Managing Cancer As a Chronic Illness for more about this.

Follow-up care

Even if there are no signs of the disease, your doctors will still want to watch you closely. It is very important to go to all of your follow-up appointments. During these visits, your doctors will ask questions about any problems you are having and may do exams and lab tests to look for signs of CML and treatment side effects. Almost any cancer treatment can have side effects. Some may last for a few weeks to months, but others can last the rest of your life. This is the time for you to talk to your cancer care team about any changes or problems you notice and any questions or concerns you have.

It is important to keep health insurance. Tests and doctor visits cost a lot, and even though no one wants to think of their cancer coming back, this could happen.

Should your cancer come back, Coping with Cancer Recurrence can give you information on how to manage and cope with this phase of your treatment.

Seeing a new doctor

At some point after your cancer diagnosis and treatment, you may find yourself seeing a new doctor who does not know anything about your medical history. It is important that you be able to give your new doctor the details of your diagnosis and treatment. Gathering these details soon after treatment may be easier than trying to get them at some point in the future. Make sure you have this information handy:

- A copy of your pathology report(s) from any biopsies or surgeries
- If you had surgery, a copy of your operative report(s)
- If you were in the hospital, a copy of the discharge summary that doctors prepare when patients are sent home
- If you had radiation therapy, a copy of your treatment summary
• If you had drug treatment (chemotherapy, interferon, or targeted therapy), a list of the drugs, drug doses, when you took them, and how your CML responded to the drug(s)

The doctor may want copies of this information for his records, but always keep copies for yourself.

• References
See all references for Chronic Myeloid Leukemia

Can I Get Another Cancer After Getting Chronic Myeloid Leukemia?

Cancer survivors can be affected by a number of health problems, but often their greatest concern is facing cancer again. If a cancer comes back after treatment it is called a recurrence. But some cancer survivors may develop a new, unrelated cancer later. This is called a second cancer. No matter what type of cancer you have had, it is still possible to get another (new) cancer, even after surviving the first.

Unfortunately, being treated for cancer doesn’t mean you can’t get another cancer. People who have had cancer can still get the same types of cancers that other people get. In fact, certain types of cancer and cancer treatments can be linked to a higher risk of certain second cancers.

People with chronic myeloid leukemia (CML) can get any type of second cancer, but they have an increased risk of:

• Oral cavity cancer
• Lung cancer
• Non-Hodgkin lymphoma

Women with CML also have an increased risk of colon cancer.
Follow-up

Most people with CML are treated with medicines that keep the disease in check without curing the disease, so they need to see their doctors regularly. Let your doctor know if you have any new symptoms or problems, as they could be from the CML getting worse or from a new disease or cancer.

All people with CML should avoid tobacco smoke, as smoking increases the risk of many cancers and might further increase the risk of some of the second cancers seen in patients with CML.

To help maintain good health, survivors should also:

- Achieve and maintain a healthy weight
- Adopt a physically active lifestyle
- Consume a healthy diet, with an emphasis on plant foods
- Limit consumption of alcohol to no more than 1 drink per day for women or 2 per day for men

These steps may also lower the risk of some cancers.

See Second Cancers in Adults for more information about causes of second cancers.

- References

See all references for Chronic Myeloid Leukemia

Lifestyle Changes After Treatment for Chronic Myeloid Leukemia

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 choices to help you stay healthy and feel as well as you can. This can 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 start during cancer treatment.

**Making healthier choices**

For many people, a diagnosis of cancer helps them focus on their health in ways they may not have thought much about in the past. Are there things you could do that might make you healthier? Maybe you could try to eat better or get more exercise. Maybe you could cut down on the alcohol, or give up tobacco. Even things like keeping your stress level under control may help. Now is a good time to think about making changes that can have positive effects for the rest of your life. You will feel better and you will also be healthier.

You can start by working on those things that worry you most. 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 for information and support. This tobacco cessation and coaching service can help increase your chances of quitting for good.

**Eating better**

Eating right can be hard for anyone, but it can get even tougher during and after cancer treatment. Treatment may change your sense of taste. Nausea can be a problem. You may not feel like eating and lose weight when you don't want to. Or you may have gained weight that you can't seem to lose. All of these things can be very frustrating.

If treatment caused weight changes or eating or taste problems, do the best you can and keep in mind that these problems usually get better over time. You may find it helps to eat small portions every 2 to 3 hours until you feel better. You may also want to ask your cancer team about seeing a dietitian, an expert in nutrition who can give you ideas on how to deal with these treatment side effects.

One of the best things you can do after cancer treatment is put healthy eating habits into place. You may be surprised at the long-term benefits of some simple changes, like increasing the variety of healthy foods you eat. Getting to and staying at a healthy weight, eating a healthy diet, and limiting your alcohol intake may lower your risk for a number of types of cancer, as well as having many other health benefits. You can read more in [Nutrition and Physical Activity During and After Cancer Treatment: Answers to Common Questions](#).

**Rest, fatigue, and exercise**
Extreme tiredness, called fatigue, is very common in people treated for cancer. This is not a normal tiredness, but a "bone-weary" exhaustion that doesn't get better with rest. For some people, fatigue lasts a long time after treatment, and can make it hard for them to exercise and do other things they want to do. But exercise can help reduce fatigue. Studies have shown that patients who follow an exercise program tailored to their personal needs feel better physically and emotionally and can cope better, too.

If you were sick and not very active during treatment, it is normal for your fitness, endurance, and muscle strength to decline. Any plan for physical activity should fit your own situation. Someone who has never exercised will not be able to take on the same amount of exercise as someone who plays tennis twice a week. If you haven't exercised in a few years, you will have to start slowly – maybe just by taking short walks.

Talk with your health care team before starting anything. Get their opinion about your exercise plans. Then, try to find an exercise buddy so 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, you will need to balance activity with rest. Sometimes it's really hard for people to allow themselves to rest when they are used to working all day or taking care of a household, but this is not the time to push yourself too hard. Listen to your body and rest when you need to. (For more information on dealing with fatigue, see Cancer-Related Fatigue and Anemia in People With Cancer.)

Keep in mind exercise can improve your physical and emotional health.

- It improves your cardiovascular (heart and circulation) fitness.
- Along with a good diet, it will help you get to and stay at a healthy weight.
- It makes your muscles stronger.
- It reduces fatigue and helps you have more energy.
- It can help lower anxiety and depression.
- It can make you feel happier.
- It helps you feel better about yourself.

And long term, we know that getting regular physical activity plays a role in helping to lower the risk of some cancers, as well as having other health benefits.

- References

See all references for Chronic Myeloid Leukemia

Last Medical Review: February 24, 2015 Last Revised: February 22, 2016
How Does Having Chronic Myeloid Leukemia Affect Your Emotional Health?

At some point, you may find yourself overcome with many different emotions. This happens to a lot of people. You may have been going through so much when you first started treatment that you could only focus on getting through each day. Now it may feel like a lot of other issues are catching up with you.

You may find yourself thinking about death and dying. Or maybe you're more aware of the effect the cancer has on your family, friends, and career. You may take a new look at your relationship with those around you. Unexpected issues may also cause concern. For instance, as you feel better and have fewer doctor visits, you will see your health care team less often and have more time on your hands. These changes can make some people anxious.

Almost everyone who has been through cancer can benefit from getting some type of 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 one-on-one counselors. 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 good for you to try to deal with everything on your own. And your friends and family may feel shut out if you do 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 1-800-227-2345 and we can put you in touch with a group or resource that may work for you. You may also want to read Distress in People with Cancer.

- References
  See all references for Chronic Myeloid Leukemia
If Treatment for Chronic Myeloid Leukemia Stops Working

If your leukemia keeps growing or comes back after one treatment, often another treatment will help. But when a person has tried many different treatments and the cancer has not gotten any better, the cancer tends to become resistant to all treatment. If this happens, it's important to weigh the possible limited benefits of a new treatment against the possible downsides. Everyone has their own way of looking at this.

This is likely to be the hardest part of your battle with cancer -- when you have been through many medical treatments and nothing's working anymore. Your doctor may offer you new options, but at some point you may need to consider that treatment is not likely to improve your health or change your outcome or survival.

If you want to continue to get treatment for as long as you can, you need to think about the odds of treatment having any benefit and how this compares to the possible risks and side effects. In many cases, your doctor can estimate how likely it is the cancer will respond to treatment you are considering. For instance, the doctor may say that more chemo or radiation might have about a 1% chance of working. Some people are still tempted to try this. But it is important to think about and understand your reasons for choosing this plan.

No matter what you decide to do, you need to feel as good as you can. Make sure you are asking for and getting treatment for any symptoms you might have, such as nausea or pain. This type of treatment is called palliative care.

Palliative care helps relieve symptoms, but is not expected to cure the disease. It can be given along with cancer treatment, or can even be cancer treatment. The difference is its purpose -- the main purpose of palliative care is to improve the quality of your life, or help you feel as good as you can for as long as you can. Sometimes this means using drugs to help with symptoms like pain or nausea. Sometimes, though, the treatments used to control your symptoms are the same as those used to treat cancer.
For instance, radiation might be used to help relieve bone pain caused by cancer that has spread to the bones. Or chemo might be used to help shrink a tumor and keep it from blocking the bowels. But this is not the same as treatment to try to cure the cancer. If you need more information about the changes that occur when treatment stops working, and about planning ahead for yourself and your family, see Nearing the End of Life and Advance Directives.

At some point, you may benefit from hospice care. This is special care that treats the person rather than the disease; it focuses on quality rather than length of life. Most of the time, it is given at home. Your cancer may be causing problems that need to be managed, and hospice focuses on your comfort. You should know that while getting hospice care often means the end of treatments such as chemo and radiation, it doesn't mean you can't have treatment for the problems caused by your cancer or other health conditions. In hospice the focus of your care is on living life as fully as possible and feeling as well as you can at this difficult time. To learn more, see Hospice Care.

Staying hopeful is important, too. Your hope for a cure may not be as bright, but there is still hope for good times with family and friends -- times that are filled with happiness and meaning. Pausing at this time in your cancer treatment gives you a chance to refocus on the most important things in your life. Now 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. Though the cancer may be beyond your control, there are still choices you can make.

- References
See all references for Chronic Myeloid Leukemia

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