

# Blood and Marrow Stem Cell Transplantation



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## A six-word narrative about living with blood cancer from patients in our LLS Community

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Stay strong and keep moving forward. Find the positive in every day. Be your own best patient advocate. Changed my life for the better. Accept, learn and focus on present. Learning to live a different life. Sudden and life changing—be positive. Waiting, worrying, anxiousness/happy I'm alive! Embrace a new normal each day. 5 years, 41 infusions, constant fatigue. Patience, positive attitude, hope and faith. Test to test, I will survive! Treatment, fatigue, treatment, fatigue and survival. Love life, live better every day. I don't look back only forward. So far, so good, live life. Meditation, mindfulness, wellness, faith, nutrition and optimism. Finding the joy while living with uncertainty. Watch, wait, treat, regroup, rest, re-energize. Blessed to be doing so well! Eye opening needed learning and healing. Feel great: uncertain travel plans annoying. Renewed faith, meditation, diet, mindfulness, gratitude. Watchful waiting can be watchful worrying. Scary, expensive, grateful, blessings, hope, faith. Thank god for stem cell transplants! Do not know what to expect. Extraordinarily grateful, I love my life. Diagnosed; frightened; tested; treating; waiting; hoping. I'm more generous, impatient less often. Embrace your treatment day after day. Live today, accept tomorrow, forget yesterday. Strength you never realized you had. Challenging to our hearts and minds. Life is what we make it. Live life in a beautiful way.



Discover what thousands already have at  
[www.LLS.org/Community](http://www.LLS.org/Community)

Join our online social network for people who are living with or supporting someone who has a blood cancer. Members will find

- Thousands of patients and caregivers sharing experiences and information, with support from knowledgeable staff
- Accurate and cutting-edge disease updates
- The opportunity to participate in surveys that will help improve care.

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Drugs may have been approved since this book was printed.  
Check [www.LLS.org/DrugUpdates](http://www.LLS.org/DrugUpdates) or call (800) 955-4572.

### Acknowledgement

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# Introduction

Hematopoietic stem cell transplantation (also known as just stem cell transplantation) is a treatment in which a patient receives healthy stem cells to replace stem cells that have been destroyed by disease or by high doses of chemotherapy and/or radiation therapy. This booklet provides information about stem cell transplantation for the treatment of blood cancers (leukemia, lymphoma, myeloma, myelodysplastic syndromes and myeloproliferative neoplasms). Brief descriptions of normal blood and bone marrow, and definitions of medical terms are also included.

Over 17,500 stem cell transplantation procedures are performed each year in the United States. As transplantation procedures and supportive care practices have advanced, stem cell transplantation has become safer, and patient survival continues to improve. Stem cell transplantation may help patients live longer, and even offers the possibility of a cure for certain blood cancers in some patients.

## Overview

For thousands of people with blood cancers, stem cell transplantation (SCT) is a potentially life-saving treatment option. Most patients who undergo SCT have blood cancers such as leukemia, lymphoma, myeloma, myelodysplastic syndromes and myeloproliferative neoplasms. Patients with bone marrow failure syndromes (for example, aplastic anemia) may also benefit from SCT.

Hematopoietic stem cell transplantation is a procedure that infuses healthy blood stem cells into the body to replace damaged or diseased stem cells. Normal blood stem cells, also called “hematopoietic stem cells,” are immature cells that produce all the blood cells in the body. Blood stem cells can either divide to form more blood-forming stem cells, or they can mature into

- Red blood cells that carry oxygen throughout the body
- White blood cells that help fight infections and cancer
- Platelets that help control bleeding

All blood cells in the body begin as immature stem cells in the bone marrow, the spongy tissue that is found in the central cavity of certain bones. New red blood cells, platelets and most white blood cells are formed in the bone marrow. Blood stem cells are constantly dividing and changing into different types of blood cells, replacing older and worn-out blood cells. They generate billions of new blood cells every day.

The production of all the body’s blood cells depends on the stem cells, the only source of all the blood cells in the body. When cancer or cancer treatment destroys a patient’s stem cells, the patient is no longer able to produce the

blood cells that are necessary for life. If the bone marrow cannot make enough new blood cells, many health problems can occur. These problems may include infections, bleeding or anemia, and can be serious enough to cause death. Stem cell transplantation can replace damaged and diseased stem cells with healthy stem cells and restore the bone marrow's ability to make new blood cells.

Blood stem cells are located in the

- Bone marrow, where most stem cells are found
- Peripheral blood, the blood circulating throughout the body
- Umbilical cords of newborn babies.

Stem cells from any of these sources can be used in stem cell transplantation. If the stem cells are collected from bone marrow, the procedure is called a “bone marrow transplantation”; when the stem cells are collected from peripheral blood, it is called a “peripheral blood stem cell transplantation”; and if stem cells are collected from an umbilical cord, it is known as an “umbilical cord blood transplantation.” Peripheral blood is the most common source of stem cells for transplantation.

To prepare for a stem cell transplantation, patients receive a conditioning regimen that consists of high doses of chemotherapy and sometimes radiation therapy. The conditioning regimen is designed to

- Provide intensive treatment to destroy cancer cells in patients with blood cancers and to destroy damaged stem cells in patients with diseases such as aplastic anemia
- Destroy blood-forming cells in the bone marrow to create space for the new, healthy stem cells.
- Suppress the patient's immune system to prevent rejection of new stem cells (if the patient receives stem cells from a donor).

The conditioning regimen, however, also destroys the stem cells that the body needs to make new blood cells. To replace these stem cells, patients receive infusions of healthy stem cells. There are two main types of transplantation. They are

- Autologous transplantation, in which a patient's own stem cells are removed, treated and returned to his or her own body after a conditioning regimen
- Allogeneic transplantation, in which a patient receives stem cells from someone other than himself or herself, such as a relative or an unrelated donor.

After the stem cells are infused into the patient's bloodstream, they travel to the bone marrow and begin the process of forming new, healthy blood cells including white blood cells, red blood cells and platelets. This process is called “engraftment.”

The main effect of stem cell transplantation is that it helps the patient recover the ability to produce stem cells after very high-dose conditioning treatments. For some types of blood cancers, however, stem cell transplantation may also work directly to destroy the cancer cells. This is called the “graft-versus-tumor” (GVT) effect, and it can occur after an allogeneic transplantation. The GVT effect can happen when white blood cells from the donor (the graft) identify the cancer cells (the tumor) that survived in the patient’s body as foreign and attack them. For some patients, GVT is crucial for the effectiveness of their treatment. It can help prevent their cancer from relapsing. The GVT effect, however, does not occur in autologous transplantation.

Unfortunately, donor stem cells in an allogeneic transplant can react against the patient’s normal cells and generate a potentially serious condition called “graft-versus-host disease” (GVHD). When the donated cells (the graft) view the healthy cells in the patient’s body (the host) as foreign, they may attack them, which can cause severe side effects. The parts of the body most commonly damaged by GVHD are the skin, intestines, liver, muscles, joints and eyes.

While a stem cell transplant can be a cure for many patients, it is very hard on a patient’s body. It can lead to severe complications or even death. It is important for patients to discuss all potential treatment options and the associated risks and side effects with the members of their healthcare team to determine if stem cell transplantation is a treatment option for them.

Transplants continue to be improved, making transplantation a treatment option for more patients each year. The estimated number of stem cell transplants in North America in 2014, by blood cancer type, is shown in **Table 1**, on *page 5*.

## Estimated Number of Stem Cell Transplants in North America, by Blood Cancer Type, in 2014

	Allogeneic (related/unrelated donor)				Autologous (patient's own cells)			
	Cell Source				Cell Source			
Disease Category	Bone Marrow	Cord Blood	Peripheral Blood	Grand Total	Bone Marrow	Cord Blood	Peripheral Blood	Grand Total
Acute Lymphoblastic Leukemia (ALL)	323	148	745	1,216	0	0	9	9
Acute Myeloid Leukemia (AML)	485	301	2,338	3,124	3	0	36	39
Chronic Myeloid Leukemia (CML)	65	19	169	253	0	0	0	0
Hodgkin Lymphoma (HL)	40	21	141	202	2	0	830	832
Leukemia, other	19	5	153	177	0	0	5	5
Multiple Myeloma/ Plasma Cell disease	18	5	203	226	1	4	6,568	6,573
Myelodysplastic Syndromes (MDSS)	151	67	854	1,072	0	0	0	0
Myelodysplastic/ Myeloproliferative neoplasms (MDS/MPN)	28	11	103	142	0	0	0	0
Myeloproliferative neoplasms (MPNs)	16	6	232	254	0	0	0	0
Non-Hodgkin Lymphoma (NHL)	87	51	643	781	2	5	2,661	2,668
	<b>Allogeneic Total</b>			<b>7,447</b>	<b>Autologous Total</b>			<b>10,126</b>
	<b>Combined Total</b>							<b>17,573</b>

**Table 1.** This table provides the estimated number of stem cell transplants in North America. Included are the totals for each type of transplant by disease category as well as the grand totals for both types of transplant by disease category.

Source: Center for International Blood and Marrow Transplant Research. Transplant Activity Report Covering 2010-2014. Table 17.

# Transplant Eligibility

Stem cell transplantation has been used to cure thousands of people who have cancer, but there are serious risks to this treatment. Some medical complications can even be life threatening, and the transplant process can also be difficult emotionally. It often requires a lengthy hospital stay and isolation from friends and family. Before undergoing stem cell transplantation, patients considering this treatment should discuss the risks and benefits with their doctors. Patients should also ask members of their healthcare team about other treatment options, including taking part in a clinical trial.

Not all patients are eligible for stem cell transplantation because not all patients can withstand the conditioning regimen and the side effects of treatment.

- High-dose conditioning regimens have been known to place great stress on the body and to cause serious damage to organs such as the heart, liver, gastrointestinal tract, kidneys, brain and lungs.
- High-dose conditioning regimens destroy the stem cells that create the white blood cells that are a part of the body's immune system. This compromises the body's immune system, leaving patients extremely vulnerable to serious infection.
- Patients receiving an allogeneic transplant are at risk for graft-versus-host disease (GVHD), a potentially serious complication that can affect quality of life and even cause death.

Some patients also may not be eligible for standard transplantation if they have other major health problems. For some of these patients, however, a reduced-intensity allogeneic stem cell transplant may be a treatment option (*see page 18*).

In order to determine if a patient is a good candidate for a stem cell transplantation, the patient's healthcare team will consider

- The patient's general health and medical condition
- The type and stage of cancer or disease
- Prior treatment history
- The likelihood that the disease will respond to the transplant
- The availability of a suitable donor or the ability to use the patient's own stem cells.

The risks of stem cell transplantation have decreased with the passing of each decade. Ongoing research is likely to continue to improve the procedure. For some diseases and patients, however, effective new drugs and new types of therapies may be better treatment options than stem cell transplantation. Doctors and their patients will consider many factors when deciding whether stem cell transplantation is the best treatment option.

**Age and Transplantation.** Younger patients often have more successful transplants. About three-quarters of people who develop a blood cancer, however, are older than age 50 years. In general, older individuals are more likely to have

- Complicating medical problems
- Difficulty treating GVHD after transplantation
- Decreased tolerance for the cumulative effects of intensive chemotherapy and radiation treatments needed before the transplant.

However, developments in transplantation with less toxic conditioning regimens such as reduced-intensity stem cell transplantation (see *page 18*), have allowed many older patients to be candidates for stem cell transplantation. There is no specific upper-age-limit cutoff for standard stem cell transplantation (although some transplant centers may have age limits).

**Timing of Transplantation and Tissue Typing.** Stem cell transplantation, once regarded as a therapy of last resort, is now considered a life-saving treatment for thousands of patients. It is being used earlier in the course of treatment for diseases that typically cannot be controlled by non stem cell therapies. The points at which transplant options are considered during an individual's disease course varies.

In many cases, the success of a transplant depends on appropriate timing. For some patients, transplantation is recommended during their first remission. For others, transplantation may be recommended later during the course of treatment, for example if there is disease that has relapsed (recurring, returned) or is refractory (resistant, or there has been poor response to treatment). This decision may depend on the response of the underlying disease to initial therapy.

If allogeneic transplantation is a consideration, it is best to have the patient's tissue typing (human leukocyte antigen [HLA] typing) done early in the disease course. The patient's siblings should also have tissue typing done. If the patient does not have a sibling HLA match, then a decision can be made about whether to enter the patient's HLA type into unrelated donor registries. Entering into an unrelated donor registry will determine whether a suitable unrelated donor match or cord blood match will be available, if needed. Half-matched (for example, a parent or child) donor transplants are also an option.

## Overview: Stem Cell Transplantation Options for Patients Who Have Blood Cancers

The following information is a general summary and is not all-inclusive. Each patient has unique circumstances, so patients should discuss all appropriate therapies with their doctors. For more detailed information, see the free LLS booklets for each of the blood cancers listed here. *Note: in all the following cases, wherever the term “suitable donor” is used, a suitable donor may also be a matching cord blood stem cell donor.*

### Acute lymphoblastic leukemia (ALL)

- The decision to perform a transplant for an adult who has ALL depends on the features of the leukemia, the patient’s general health and the patient’s age.
- An allogeneic stem cell transplant may be an option for patients with high-risk ALL whose disease is in remission for the first time or whose disease is in a partial remission (provided a suitable donor is available).
- The choice between allogeneic transplantation and continued chemotherapy is less clear for patients who have standard-risk ALL and whose disease is in first remission. These patients should discuss standard and/or reduced-intensity allogeneic stem cell transplantation with their doctors to determine if either of these types of transplants are recommended for them. A minimal amount of residual disease may influence the decision of whether or not to proceed to transplantation.
- Autologous stem cell transplantation outside of the clinical-trial setting is not recommended as treatment for ALL.
- Most children with ALL (about 75 to 80 percent) do not need stem cell transplantation. A child with refractory disease or relapsed ALL may be considered for allogeneic transplantation.

### Acute myeloid leukemia (AML)

- Favorable-risk AML: Stem cell transplantation is generally not recommended with first complete remission.
- Intermediate-risk AML: Patients with intermediate-risk AML should discuss standard and/or reduced-intensity stem cell allogeneic transplantation with their doctor to determine if one of these transplantations is recommended for them.

- High-risk AML: Allogeneic stem cell transplantation is generally recommended with first remission or in a partial remission for patients who are candidates for a transplant and have a suitable allogeneic donor. Reduced-intensity allogeneic stem cell transplantation may be recommended for older patients or patients who have certain comorbidities.
- Autologous stem cell transplantation outside of a clinical-trial setting is not commonly used to treat AML.

### **Chronic lymphocytic leukemia (CLL)**

- Allogeneic transplantation (usually reduced-intensity but sometimes standard) is under study in clinical trials as treatment for patients who have CLL that has certain high-risk features or disease that has relapsed after standard therapies.

### **Chronic myeloid leukemia (CML)**

- In cases of either advanced or refractory disease or intolerance of oral CML therapies, standard allogeneic stem cell transplantation (or reduced-intensity allogeneic stem cell transplantation) may be recommended for patients who have a suitable allogeneic donor available.

### **Hodgkin lymphoma (HL)**

- Autologous stem cell transplantation is used to treat HL patients whose disease relapses after initial therapy.
- Standard and reduced-intensity allogeneic stem cell transplantation are under study in clinical trials as treatment for HL patients who have a suitable allogeneic donor.

### **Non-Hodgkin lymphoma (NHL)**

- Autologous stem cell transplantation is generally used to treat patients who have relapsed or refractory disease; transplantation during first remission is done only in clinical trials, with the exception of some types of NHL, including certain cases of mantle cell lymphoma and T-cell lymphoma.
- Allogeneic transplantation is used to treat selected patients who have NHL.
- Patients should check with their doctors and find out if there are specific recommendations for their subtype of NHL.

## Myelodysplastic syndromes (MDSs)

- A standard allogeneic stem cell transplant (or a reduced-intensity allogeneic stem cell transplant for older or other selected patients) may be recommended for people who have intermediate- or high-risk MDS and a suitable allogeneic donor available.

## Myeloma

- Autologous stem cell transplantation is an important part of treatment for certain myeloma patients.
- Allogeneic stem cell transplantation is not commonly used for myeloma patients but it may be a treatment option for selected younger patients who have a suitable allogeneic donor available.
- Reduced-intensity allogeneic stem cell transplantation is used in some cases following autologous stem cell transplantation for patients who have a suitable allogeneic donor available.

## Myeloproliferative neoplasms (MPNs)

- Myelofibrosis: A standard allogeneic stem cell transplant (or a reduced-intensity allogeneic stem cell transplant for older patients or patients who have certain comorbidities) may be recommended for patients who have a suitable allogeneic donor available.
- Polycythemia vera (PV) and essential thrombocythemia (ET): Allogeneic stem cell transplantation and reduced-intensity allogeneic stem cell transplantation are occasionally used to treat these diseases.

# Preparing for Transplantation

**Medical Tests.** Stem cell transplantation is a rigorous medical procedure. Before undergoing transplantation, patients will be given a number of medical tests to ensure that they are healthy enough for the procedure. Some of these tests may include

**Chest x-ray.** A chest x-ray provides information about the size of the heart and lungs, and it may also detect the presence of infection or lung disease.

**Pulmonary function test.** A pulmonary function test is a breathing test used to measure how well the lungs are working.

**Electrocardiogram (EKG).** To evaluate the heart's rhythm, electrodes (flat, sticky patches) are placed on the chest for this test.

**Echocardiogram (ECHO).** Using ultrasound waves to create a picture, echocardiograms show the size, shape, and position of the heart. The test also shows the parts inside the heart such as the valves and the motion of the heart while it is beating.

**Blood tests.** Blood tests are used to evaluate kidney and liver function, thyroid function, blood counts, and hemoglobin levels. These tests also show past exposure to certain infectious diseases, such as human immunodeficiency virus (HIV) and cytomegalovirus (CMV). These tests also screen for viral and bacterial infections.

**Urine tests.** Urine tests are used to measure kidney function.

**Computed tomography (CT or CAT) scans.** Computed tomography scans are x-rays that provide detailed images of the body including soft tissue and bone.

**Skeletal survey.** A skeletal survey is a series of x-rays of major bones. It is used to check for any signs of disease and is usually done for patients with myeloma.

**Bone marrow aspiration and biopsy.** These tests are done to evaluate how well the bone marrow is producing blood cells and to check for any signs of cancer in the bone marrow. The samples are usually taken from the patient's hip bone (a local anesthetic is given to numb the area). Bone marrow has both a solid and liquid part. For a bone marrow aspiration, a special hollow biopsy needle is inserted through the hip bone and into the marrow to remove (aspirate) a liquid sample containing cells. For a bone marrow biopsy, a specialized wider needle is used so that a core sample of solid bone that contains marrow can be removed. These two tests are almost always done together.

**Lumbar puncture.** This is a procedure that is used to check for abnormal cells in the fluid that surrounds the brain and spinal cord called the "cerebrospinal fluid." A thin needle is inserted into the lower part of the spinal column and a small amount of cerebrospinal fluid is collected. A lumbar puncture is done only for certain types of leukemia and lymphoma.

**Dental examination.** A dental checkup is needed to ensure that any dental problems, such as cavities, loose fillings or gum disease, are resolved before the transplantation.

**Caregiver.** It is important for patients preparing for transplantation to choose a caregiver. Patients who undergo stem cell transplantation will need an adult caregiver who will be responsible for some of the medical, emotional and daily support during recovery. Sometimes a caregiver is one person, but often several people can help at different times throughout the process. A caregiver can be a spouse, partner, sibling, parent, adult child or a close friend. A caregiver should be with the patient all the time once the patient is discharged from the hospital in case unexpected complications arise and help is needed. Members of the patient's healthcare team will teach the caregiver(s) the necessary skills to care for the patient.

Once the patient returns home, the caregiver will need to be prepared to help him or her by providing

**Medical Support.** The caregiver(s) may have to

- Ensure that the patient takes the correct dose of medication at the right time.
- Notice any changes in the patient's condition.
- Monitor the patient for new symptoms and immediately report them to the patient's medical team. Some conditions, such as infections and graft-versus-host disease, need to be treated quickly. The caregiver should be aware of symptoms and know the phone numbers to call during office hours, at night and on weekends.
- Call for medical help in an emergency.

**Emotional Support.** The caregiver(s) should

- Pay close attention to the patient's moods and feelings.
- Listen, and then be supportive.
- Keep family and friends informed about the patient's progress.

**Practical Support.** The caregiver(s) should anticipate that it may be necessary for them to

- Prepare meals and clean the house.
- Provide transportation to medical appointments. After discharge from the hospital, patients need to make frequent medical appointments. The caregiver will need to provide transportation and accompany the patients to the appointments.
- Assist with the patient's daily activities including, if necessary, caring for pets.
- Assist with financial and insurance issues and manage transplant costs.
- Ensure that household bills are paid on time.
- Manage the number of visitors and keep the patient away from anyone who is sick.

**Cost of Transplantation.** Stem cell transplantation is a very expensive procedure. As soon as a stem cell transplant is being considered as a treatment option, patients should discuss financial issues with their treatment team. Transplant centers have staff members who can help patients to get answers for financial questions concerning health insurance and financial assistance.

Most insurance plans cover some of the costs of transplantation for certain cancers or diseases. Before undergoing transplantation, patients should contact their medical insurance providers and determine which costs the insurance provider will cover. If their insurance company denies coverage for a recommended treatment, procedure, or prescription medication, patients may be able to get the decision

overturned by filing an appeal with their insurance company. If claims are repeatedly denied, patients may want to contact their state's insurance agency or an attorney.

Patients in need of financial assistance should talk with their transplant teams about organizations that offer financial assistance to patients who qualify. Caregivers can also help patients find alternate sources of financial assistance. Call an LLS Information Specialist at (800) 955-4572 for additional resources.

In addition to medical bills, both patients and caregivers may need to plan for taking time away from work. Patients and their caregivers may be eligible to take unpaid, job-protected leave with continuation of group health insurance coverage under the Family and Medical Leave Act. Patients and caregivers should contact their workplace human resources department to see if they are eligible under this law.

Some patients may be eligible for Social Security Disability (SSD) benefits. The Social Security Administration (SSA) pays a monthly cash benefit to individuals who are unable to work (disabled) due to a severe medical condition that has either lasted, or is expected to last, at least one year. According to the SSA guidelines, treatment with a stem cell transplant is considered a disability. To learn more about SSD, patients can go to [ssa.gov/disability](http://ssa.gov/disability) or call (800) 772-1213. Many transplant patients receive SSD during the course of their treatment and recovery and then, once they are able to return to work, these social security disability benefits will be discontinued.

Some patients may receive disability insurance through their employers. Sometimes these disability plans are automatically offered as part of an employee's benefit plan. Sometimes, the employee is required to purchase this insurance. Patients should contact their human resources department to see whether they either have, or are eligible for, disability benefits.

**Fertility.** High doses of chemotherapy and radiation can affect cells in both male and female reproductive systems. Recovery from stem cell transplantation may take months to years, and patients of childbearing age may not be physically or psychologically ready to think about parenthood for several years after transplantation. Patients who may want to have children in the future should discuss options to preserve fertility before transplantation.

- **Male fertility**—Men may consider preserving their fertility before transplantation by having their sperm collected and frozen for future use. The sperm will be collected before the conditioning regimen is started.
- **Female fertility**—Most female patients experience either temporary or permanent menopause as a side effect of transplantation. Patients who have already received chemotherapy or radiation therapy prior to transplantation, may or may not be fertile. Women who are interested in trying to preserve their fertility should schedule an appointment with a fertility specialist before starting treatment.

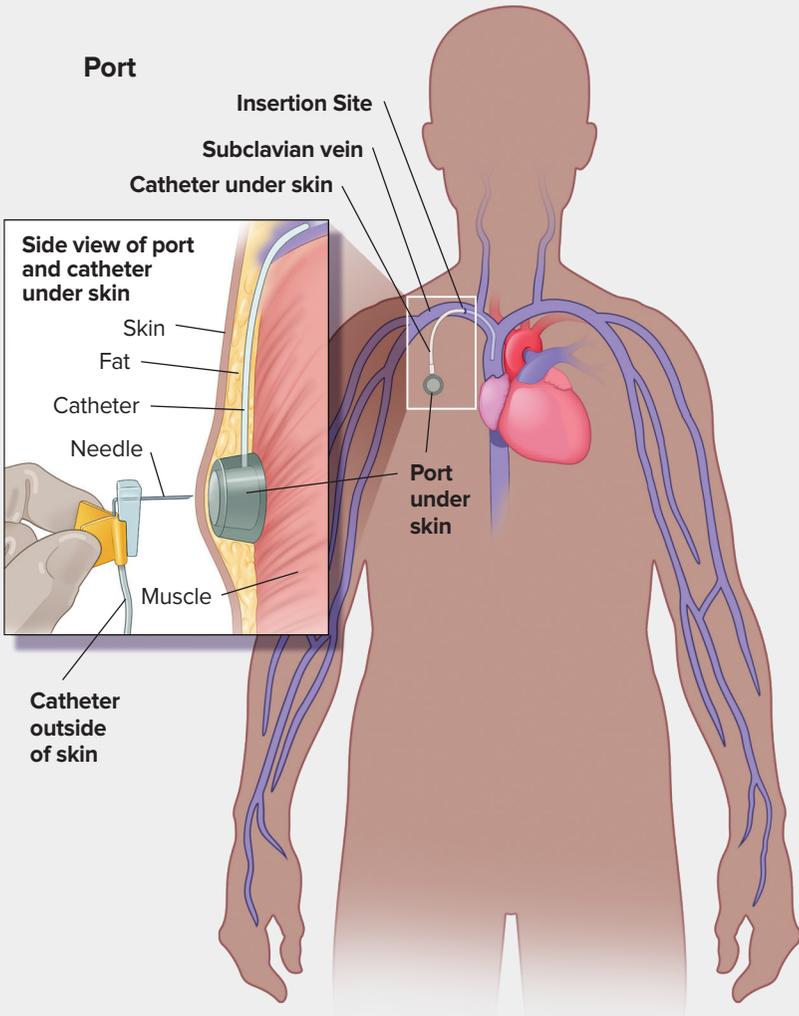
One option for women is having their eggs frozen. Mature eggs are stimulated, removed and frozen, either unfertilized or fertilized with sperm. Another option is available for girls who do not yet have mature eggs and for women who must start treatment immediately and who do not have time to undergo egg retrieval; they can have ovarian tissue removed (during an outpatient surgical procedure) and then frozen for future transplantation back into the body. This method is considered experimental, but the goal is preserving enough immature eggs to save female fertility.

**For more information, see the free LLS booklet, *Fertility Facts*.**

**Insertion of a Central Venous Catheter.** During the transplantation process, a patient will need to have a number of intravenous (administered directly into a vein) infusions. In addition to the infusion of stem cells, patients may also receive other infusions, including fluids, chemotherapy, antibiotics, other drugs and transfusions of red blood cells and platelets. Patients will also need to have blood drawn frequently for testing to monitor their progress. These injections, if given individually, would be painful and the veins in the hands and arms could not sustain so many frequent needle pricks. Therefore, prior to the transplantation, patients will have a central line (central venous catheter [CVC]) inserted if they do not have one already.

A CVC is a tube that is inserted through the skin into a large vein, usually in the upper chest. Placement is usually done under local anesthesia. To place the CVC, a small incision is made where the catheter (tubing) enters the vein and the catheter runs all of the way to a large vein near your heart. Small, clear dressings are changed frequently to prevent infection. Having a CVC makes treatment more comfortable. Depending on the frequency of later blood draws, the CVC may be changed to a port-a-cath (also referred to as a “port”). A port-a-cath is a two-part venous access device--a self-sealing portal and the catheter. It is surgically implanted under the patient’s skin (see **Figure 1** on *page 15*). A port-a-cath offers lower risk of infection and allows the patient more freedom in activities of daily living.

# Port and Catheter



**Figure 1.** This picture shows where a port would be placed on the chest and how a member of the healthcare team would use the port to access the catheter under the skin, via the port.

# Types of Stem Cell Transplantation

Depending on a patient's disease and health status, the doctor may recommend either an autologous or an allogeneic stem cell transplantation. The decision about which treatment to use is complex, and the factors that must be considered are different for each patient. Therefore, the decision should involve a thorough discussion between patient and doctor.

**Autologous Stem Cell Transplantation.** In autologous stem cell transplantation, the procedure uses the patient's own stem cells for the transplant. See **Figure 2** on *page 17*. The stem cells are collected from the patient in advance and are frozen. After the patient undergoes high doses of chemotherapy, either with or without radiation therapy, the stem cells are then returned to the body. This type of transplant is often used to treat blood cancers such as Hodgkin lymphoma, non-Hodgkin lymphoma and myeloma.

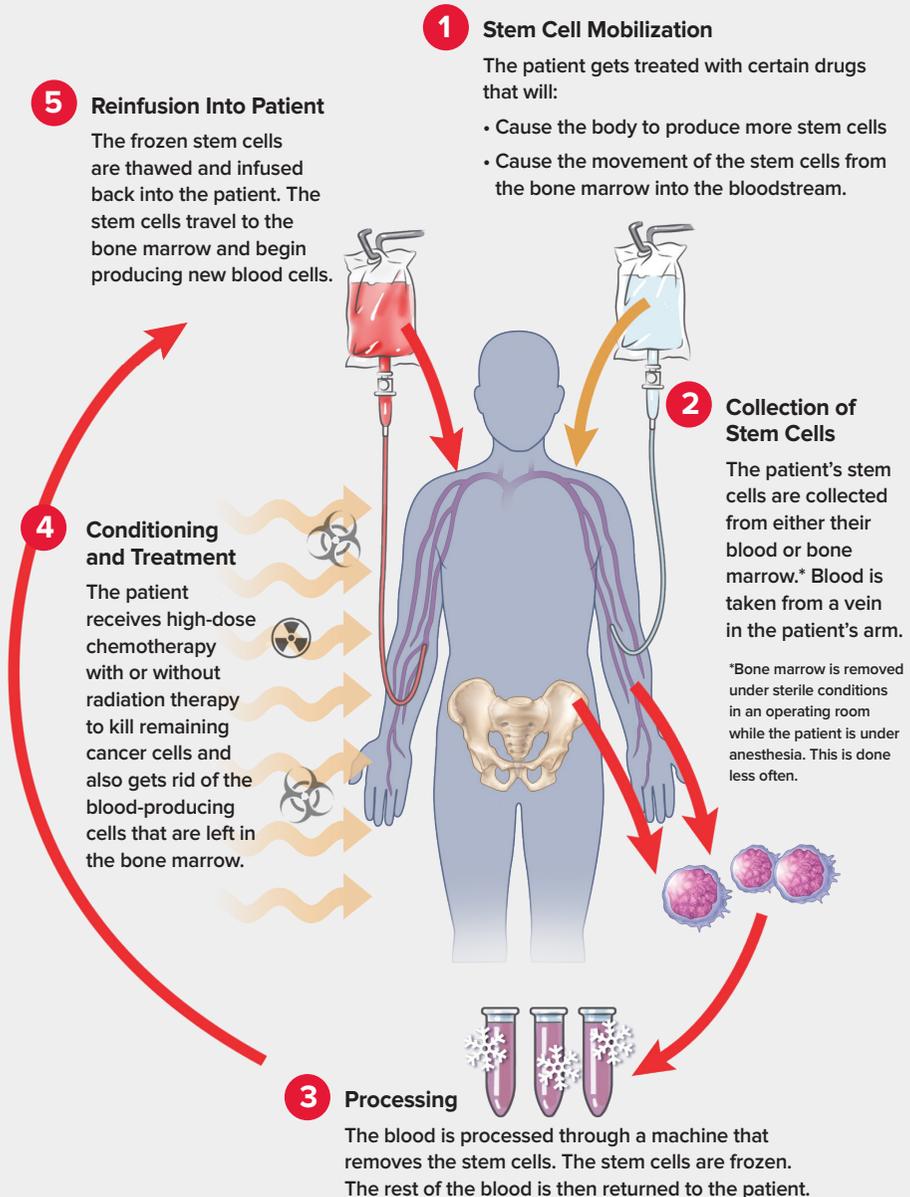
The primary purpose of an autologous transplantation is to allow the patient to receive high doses of chemotherapy either with or without radiation. This is called the "conditioning regimen." Such intensive treatments usually destroy cancer cells better than standard treatments, but these high-dose treatments are toxic and also destroy the blood-producing stem cells in the bone marrow. That is why the stem cells are removed before the treatment. The infusion of the patient's own healthy stem cells can restore the bone marrow's ability to make new blood cells and reestablish the patient's immune system.

After the stem cells have been treated outside the body, they are reinfused and they will travel to the bone marrow where they can make new blood cells. This is called "engraftment." Engraftment occurs more quickly in an autologous transplantation than in an allogeneic transplantation. The frozen cells are the patient's own stem cells, so graft failure (when the transplanted cells do not successfully grow and divide in the bone marrow) is rare, and graft-versus-host disease (GVHD) is never a problem.

Autologous transplantation, however, cannot produce the graft-versus-tumor effect that patients may obtain from an allogeneic (donor) transplantation. As a result, there is a higher risk of relapse of the disease.

Most people have a single autologous transplant. Others may have a transplant called a "tandem transplant." A tandem transplant involves a planned second autologous stem cell transplant after the first autologous transplant. All the stem cells are collected from the patient before the first-high dose chemotherapy treatment. After the first transplant, half of these stem cells are infused into the patient's body. Usually, several weeks or months pass before the second course of high-dose chemotherapy. After the second course, the other half of the healthy stem cells that were originally removed are infused. This method is under study in clinical trials for the treatment of several types of cancer, including myeloma.

# Autologous Stem Cell Transplantation



**Figure 2.** This illustration shows the autologous stem cell transplantation process. Once the stem cells are collected from the donor (patient), the cells are mixed with a cryoprotective agent so that they can be frozen (for many years) and then later thawed without injury. Once the patient has completed the conditioning treatment, the frozen stem cell collection is thawed and infused into the patient so that blood cell production can be restored.

**Standard Allogeneic Stem Cell Transplantation.** This type of transplantation involves the use of stem cells from someone other than the patient. See **Figure 3** on *page 19*. The donated stem cells can come from either a related or an unrelated donor. This type of transplant is often used to treat blood cancers such as leukemia, myelodysplastic syndrome, myeloproliferative neoplasms and aplastic anemia.

Before an allogeneic stem cell transplantation, the patient receives a conditioning regimen of chemotherapy and, sometimes, radiation therapy. This conditioning treatment is given to destroy any remaining cancer cells in the body. This helps weaken the patient’s immune system to help keep the body from rejecting the donated cells after the transplant. It also allows the donor cells to move through the bloodstream to the bone marrow, where the donor cells will begin to grow and produce new blood cells, including red blood cells, platelets and white blood cells. This process is called “engraftment.”

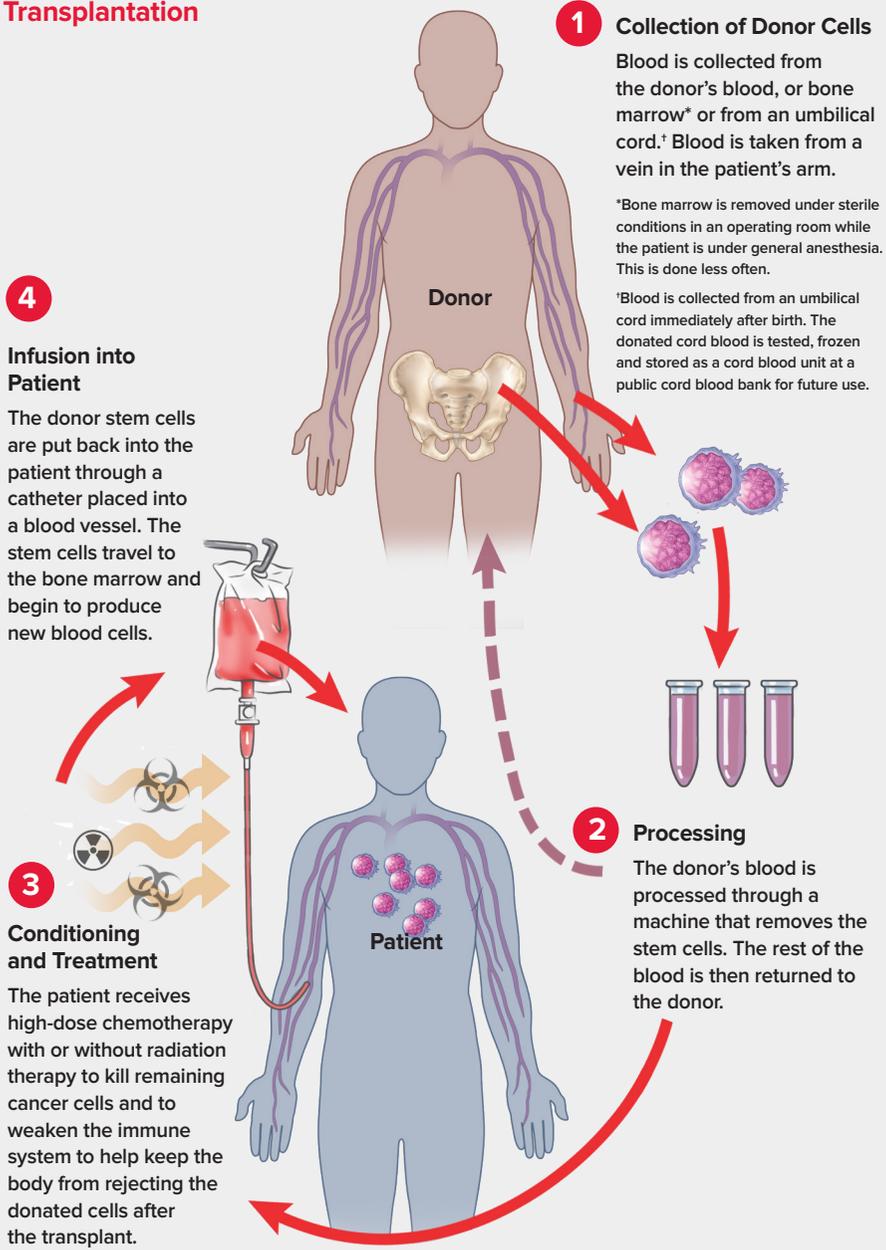
When a transplant is successful, the donor stem cells can replace stem cells in the bone marrow. It may also provide the only long-term cure of the patient’s disease. One of the benefits of allogeneic stem cell transplantation is that after the donated cells engraft in the patient, they create a new immune system. The donated cells produce white blood cells that attack any remaining cancer cells in the patient’s body. This is called the “graft-versus-tumor effect.” and it may be even more important than the very intensive conditioning regimen that is administered to destroy the cancer cells. This benefit can only occur in allogeneic stem cell transplantation.

One complication of allogeneic transplantation is that the patient’s body—despite the treatment to suppress the immune system—may reject the donated stem cells before they are able to engraft in the bone marrow. The patient’s immune cells may see the donor’s cells as foreign and destroy them.

Another complication of allogeneic transplantation is that the immune cells from the donor (the graft) may attack healthy cells in the patient’s body (host). This is called “graft-versus-host disease” (GVHD). The parts of the body that are most commonly damaged by GVHD are the skin, intestines, liver, muscles, joints and eyes. Graft-versus-host disease can be mild, moderate or severe. There are treatments for GVHD, but in some patients, GVHD does not respond to treatment and can be fatal. See *Graft-Versus-Host Disease* on *page 33*.

**Reduced-Intensity Allogeneic Stem Cell Transplantation.** Reduced-intensity allogeneic transplantation (sometimes called “mini-transplant” or “nonmyeloablative transplant”) uses lower, less toxic doses of chemotherapy and radiation than the conditioning regimen that is given before standard allogeneic transplantations. This type of transplant may be an option for certain patients who are older, who have organ complications or who are otherwise not healthy or strong enough to undergo standard allogeneic transplantation. With a reduced-intensity conditioning regimen, the patient’s blood counts may not fall as low as they would with high-dose chemotherapy. Additionally, the less toxic regimens put

# Allogeneic Stem Cell Transplantation



**Figure 3.** This illustration shows the allogeneic stem cell transplantation process. Once the stem cells are collected from the donor, the cells are mixed with a cryoprotective agent so that they can be frozen (for many years) and later once a patient is identified and the cells are needed, the cells can be thawed without injury and shipped to the patient.

less strain on the patient's major organs, making this regimen more tolerable and safer. Sufficient numbers of reduced-intensity allogeneic stem cell transplants have been performed to conclude that it may be an appropriate treatment for certain older, sicker patients who cannot tolerate a high-dose conditioning regimen.

The success of reduced-intensity transplantation depends on the graft-versus-tumor (GVT) effect of the donor stem cells, rather than on high-dose treatments to kill the cancer cells. The goal is to have the donor stem cells take up residence in the recipient's marrow and produce lymphocytes (white blood cells, part of the immune system) that will attack the patient's remaining blood-cancer cells.

The conditioning regimen for a reduced-intensity allogeneic transplantation does not destroy as many cancer cells as the regimen for a standard allogeneic transplantation. But this conditioning regimen—along with potent drugs to suppress the patient's immune system—should weaken the patient's immune system enough so that it cannot attack and reject the donor cells, allowing the donor cells to take over the bone marrow and produce a new immune system to fight the cancer.

In some instances, blood cells from both the donor and the patient may exist in the patient's bone marrow for some time after transplantation. When the donor's immune system does not completely replace that of the patient (a state called "mixed chimerism"), the patient may be given an injection of the donor's lymphocytes (white blood cells) to improve engraftment and possibly the immune system's antitumor effects. This procedure is called a "donor lymphocyte infusion" (DLI).

Reduced-intensity allogeneic transplantations carry many of the same risks as standard allogeneic transplantations. One risk is that the patient's body may reject the donated stem cells before they are able to engraft in the bone marrow. The patient's immune cells may see the donor's cells as foreign and destroy them before engraftment can begin. Another risk is that the immune cells from the donor (the graft) may attack healthy cells in the patient's body (host). This is called "graft-versus-host disease" (GVHD). See *page 33*.

Research shows that reduced-intensity allogeneic transplants may be effective in treating certain patients with chronic myeloid leukemia (CML), acute myeloid leukemia (AML), non-Hodgkin lymphoma (NHL), chronic lymphocytic leukemia (CLL), or myelodysplastic syndromes (MDSs). The doctor will discuss with a patient whether a reduced-intensity allogeneic transplant is an option for him or her.

**Tissue Typing for Allogeneic Transplantation.** Once it is determined that allogeneic stem cell transplantation is a treatment option for a patient, the patient's treatment team will begin to search for a suitable donor. For most patients, the success of allogeneic transplantation depends, in part, on how well the donor's tissue type matches the patient's tissue type. Historically, patients who are not well matched have high rates of graft failure and graft-versus-host disease, and very poor survival.

People have different sets of proteins or markers called “human leukocyte antigens” (HLAs) on the surface of most cells. The immune system uses these markers to identify which cells belong in the body and which cells do not. A blood test is used for HLA typing. The findings determine how closely the tissue type of one person matches the tissue type of another person.

A close match is important because it improves the chances for a successful transplant. The more markers two people share, the greater the chance that their immune systems will not view each other as foreign and they will be less likely to attack each other. When the patient’s immune system is less likely to attack the donor cells, those new cells can engraft (grow and make new blood cells in the bone marrow). A closer match also reduces the risk of graft-versus-host disease, a complication in which the donor cells attack the patient’s healthy cells.

There are many HLA markers but HLA typing is usually based on either 8, 10 or 12 HLA markers. When two people share the same HLA markers, they are considered to be a good match. In many transplant centers, doctors may require at least 6 or 7 of the 8 markers to match in order to perform the transplantation.

Individuals inherit half of their HLA markers from their mothers and half from their fathers, so often the ideal donor is a patient’s sibling who has inherited the same HLA markers. On average, a person has one chance in four of having the same HLA type as his or her sibling, but many patients will not have a sibling with the same tissue type. Although an HLA-matched sibling is the preferred donor, only about 30 percent of patients have such a donor available.

For those patients without a matched family donor, an unrelated donor may be found through a volunteer donor registry. Donor registries are in place to identify an unrelated donor who has a tissue type that matches the patient’s tissue type. The *Be The Match* Registry®, operated by the National Marrow Donor Program®, in partnership with international and cooperative registries, provides doctors with access to nearly 27 million potential donors and more than 680,000 cord blood units worldwide. Unfortunately, well-matched HLA donors and cord blood units are not always available for patients, even with these large registries. Therefore, researchers are studying ways to increase the pool of potential donors.

**Cord Blood.** Cord blood may be a viable alternative source of stem cells for patients without a well-matched related or unrelated donor. Unfortunately, cord blood units tend to contain fewer stem cells and may be difficult to use in people with larger body sizes. In addition, this smaller cell dose and more immature immune cell system tends to be linked to longer times to engraftment and associated with higher risks of infection. These problems may make these transplants more dangerous for some patients than for others. Cord blood, however, has a major advantage over matched unrelated donors; it is available much more quickly (potentially within 2 to 4 weeks) while it may take a month or more to obtain matched unrelated donor grafts. The time element is extremely

important in high-risk blood cancers because the disease could relapse while the patient is waiting for a transplant. Which donor type of transplant (matched unrelated, cord blood, or half-matched) will ultimately lead to the best outcome is still unclear, and is an area of active investigation.

Another advantage of cord blood transplants is that cord blood may require a lower level of HLA matching between the donor and recipient. When compared with other transplants, those using the less mature stem cells from cord blood seem to be associated with a decreased risk of GVHD and therefore have a less strict matching criteria. For this reason, umbilical cord blood stem cell transplants may be considered when a well-matched donor cannot be found.

Research is under way to improve the yield of cord blood stem cells and to examine the use of more than one cord blood unit per transplant to see if this improves the time to engraftment. See the free LLS booklet *Cord Blood Stem Cell Transplantation Facts* for more information.

**Haploidentical Transplantation.** To increase the number of potential donors, some transplant centers have begun to perform half-match (haploidentical) transplant, for patients who cannot find a closely matched HLA donor. In many cases a healthy, first-degree relative (a parent, sibling or child) can donate stem cells, even if they are only a half match. Since a child receives half of his or her HLA markers from a parent, a biological child and his or her parent will always be a half match, while there is a 50 percent chance of a sibling being a half match. Consequently, most individuals will have a suitable related haploidentical donor.

In addition to making it easier to find a suitable donor, the use of haploidentical stem cells is valuable because half-matched stem cells are often available much more quickly than a match from unrelated donor stem cells. Relatives may be able to make a donation on short notice, which may be less likely with an unrelated donor. This is important in cases when timing can be crucial, especially for a patient with a high-risk blood cancer when there is potential of disease relapse while the patient waits for transplantation.

However, since the patient and the donor are only half matched, the patient is at greater risk for graft failure and graft-versus-host disease. To try to prevent these complications, the doctor will remove some of the T cells from the donor stem cells. Researchers are also studying the use of the drug cyclophosphamide (Cytoxan®), administered shortly after the infusion of the stem cells, to try to eliminate some of the donor T cells.

Researchers are studying haploidentical transplants as a viable option for increasing the numbers of potential donors for patients who need a stem cell transplant. Haploidentical transplants are still uncommon, but researchers are studying this procedure with the hope that it can become a more available and safer option for patients.

**Syngeneic Stem Cell Transplantation.** This term is used to describe allogeneic transplantation when the donor and recipient are identical twins. Identical twins represent a small number of all births, so syngeneic transplantation is rare. Identical twins have the same genes, so they have the same tissue type. With this kind of transplantation, donor cells are not rejected and the patient's tissues are not attacked by the donor's immune cells. Typically, engraftment is associated with faster blood cell recovery and a quicker return of the immune system. No treatments are needed to prevent graft rejection or GVHD. The only disadvantage of a syngeneic stem cell transplant is that—just as with autologous transplantation—there is no graft-versus-tumor effect that would help to prevent a relapse of cancer.

## Stem Cell Collection for Transplantation

**Overview.** There are three possible sources of stem cells for transplantation. They are

- Peripheral blood
- Bone marrow
- Umbilical cord blood.

The patient's doctor determines the appropriate source, based on the patient's disease and health status. All donors are carefully screened to prevent any transmissible diseases and detect other medical problems that might prevent them from donating stem cells. Remember that the donor may be the patient (autologous transplantation) or another person (allogeneic stem cell transplantation).

**Peripheral Blood Stem Cell Collection.** The stem cells used in a peripheral blood transplantation are collected from the bloodstream. It is the most common source of stem cells for both autologous and allogeneic stem cell transplantations. Collecting stem cells from the bloodstream is a nonsurgical procedure that involves less pain, no anesthesia, and no hospital stay so it is easier on the donor than the more painful and complex procedure involved in removing stem cells from the bone marrow.

Another benefit of using a peripheral blood stem cell transplant is that after these cells are transplanted, they engraft and begin working more quickly than cells that are taken from the bone marrow. One major disadvantage of using peripheral blood stem cells however, is that it is associated with a greater risk of graft-versus-host disease in allogeneic transplantations.

To obtain peripheral blood stem cells for transplantation, the donor undergoes the process of stem cell mobilization (to increase release of stem cells) and apheresis (collection of stem cells).

**Stem Cell Mobilization.** Most stem cells are located in the bone marrow. Normally, the bone marrow only releases a small number of stem cells into the bloodstream. To obtain enough stem cells from the peripheral blood for transplantation, the donor is given certain drugs that stimulate the mobilization (release) of stem cells from the bone marrow into the blood. Starting 4 to 5 days before the stem cell collection, the donor is given daily injections of drugs called “granulocyte-colony-stimulating-factors” (G-CSFs) such as filgrastim (Neupogen®) or (Zarxio®), lenograstim (Granocyte®), and pegfilgrastim (Neulasta®). Using G-CSFs greatly increases the chances of collecting enough stem cells for the transplant. Granulocyte-colony stimulating factors may cause some side effects for the donor, including bone and muscle aches, headaches, fatigue, nausea, vomiting, and/or difficulty sleeping. These side effects generally stop within 2 to 3 days of the last dose of the medication.

In some cases, when the patient is the donor, and the patient’s own stem cells are used for the transplant (autologous transplant), the stem cells are mobilized by a combination of the chemotherapy used to treat the underlying disease and G-CSFs. In patients who have myeloma or non-Hodgkin lymphoma, the drug plerixafor (Mozobil®) may be given to mobilize stem cells for an autologous transplant in conjunction with filgrastim. Plerixafor may have additional side effects for the patient, including abdominal discomfort and diarrhea.

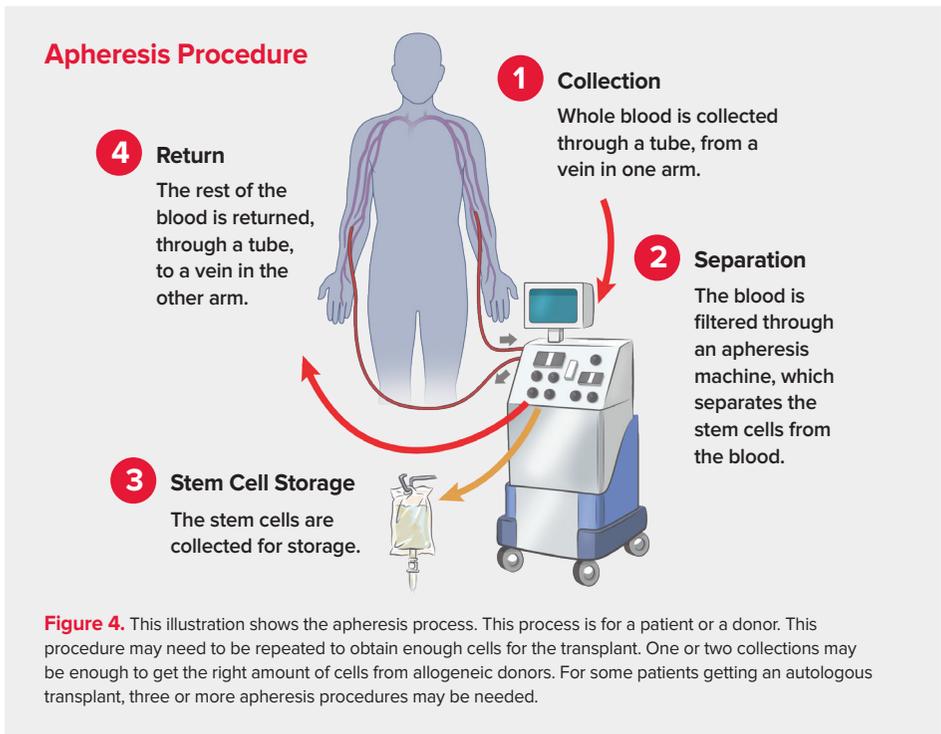
**Apheresis.** Once the stem cells are mobilized, they are collected from the blood of the patient/donor using a process called “apheresis”. See **Figure 4** on *page 25*. The blood is removed from one of the donor’s large veins (most likely from the arm) via a central venous catheter. The blood is then circulated through an apheresis machine, which separates the blood into four components: red blood cells, plasma, white blood cells and platelets. The white blood cells are collected because they contain the stem cells. The rest of the blood is returned to the patient’s/donor’s body.

The number of stem cells that must be collected depends on the patient’s/donor’s weight and the disease for which the transplant is being performed. Stem cell collection is typically completed for an allogeneic transplant (from a donor other than the patient) after one or two sessions.

In autologous stem cell collections, (where the blood is collected from the patient) if the patient has undergone prior chemotherapy, sometimes the collection of enough stem cells may require more than two apheresis sessions. When too few cells have been collected for an autologous transplantation, the patient may undergo treatment with either the same or different mobilization drugs. Then another attempt is made to collect the necessary numbers of stem cells.

Apheresis usually takes 4 to 6 hours, does not require anesthesia, and it usually causes minimal discomfort. It may take two or more sessions to obtain sufficient stem cells for transplantation. Side effects for the patient/donor that may occur

during the procedure include chills, lightheadedness, numbness around the lips and cramping in the hands. Patients and donors typically tolerate apheresis well. During the procedure, an anticoagulant mixes with the patient's/donor's blood to keep it from clotting while it is circulating through the machine. The anticoagulant lowers the calcium level in the blood and the lower calcium levels can occasionally cause sensations of coldness, numbness and tingling of the lips and fingers, and/or nausea. These side effects are temporary, but it is important for the patient and/or donor to let the apheresis technician or nurse know if he or she is having any of these symptoms during the procedure, as the patient/donor may need calcium.



For an allogeneic stem cell transplantation, if the stem cells are to be used immediately, they are placed in a plastic bag and, within a few hours, infused directly into the patient. If the donor is not located near the patient, the stem cells will be transported or they can be frozen and stored. For autologous transplantation, the patient's own stem cells will be frozen and then stored until they are infused.

**Bone Marrow Aspiration.** In certain situations, especially in allogeneic transplantations, stem cells harvested from the donor's bone marrow may be preferred in order to lower the risk of graft-versus-host disease.

If stem cells are collected from the bone marrow, a procedure called “bone marrow aspiration” is done. Bone marrow donation is a surgical procedure and is performed in an operating room, using either regional or general anesthesia. The doctor uses a special hollow needle that is attached to a syringe. He or she inserts the needle through the skin into one or more areas of the hip bone and withdraws bone marrow from the top edge of the hip bone of the donor. Several pints of marrow are removed. The donor usually remains in the hospital for about 6 to 8 hours, including recovery time. During this time, the donor recovers from both the anesthesia and the acute pain at the needle insertion sites. Typically, the donor can expect to feel soreness in the lower back, which will improve slowly over a few weeks or, perhaps, longer. Most donors are able to return to their normal routine within a week. Side effects from the anesthesia for the donor may include nausea, headache and fatigue.

The donor stem cells are collected in a plastic blood transfusion bag. If stem cells are being retrieved from bone marrow, special filters are used to separate bone fragments, fatty particles and large clusters of cells from the collected stem cells before the product is placed into the transfusion bag. This is done in the operating room or in the laboratory. The product is then sent to either a blood bank or cell-processing laboratory where

- The number of cells is determined
- Either the red blood cells or the plasma (the fluid surrounding the cells) may be removed if the donor and recipient do not share the same red blood cell type.

The stem cells can be administered to the patient within 24 hours. If necessary, the harvested bone marrow cells can be frozen and stored for later use.

**Umbilical Cord Blood.** The blood in the umbilical cord and placenta contains stem cells. This blood is collected after the baby is born; the collected blood is called a “cord blood unit.” During delivery, the focus is on the mother and baby. After the baby is delivered, the umbilical cord is clamped. The blood from the umbilical cord and placenta is collected either before or after the placenta is delivered, depending upon the procedure at the hospital. The cord blood is collected into a sterile bag; this bag of blood is the cord blood unit. The cord blood unit is given an identification number and stored temporarily. The cord blood unit is transported to a cord blood bank for testing, freezing and long-term storage.

Testing procedures include HLA tissue typing to determine the level of matching to potential recipients, blood cell counts and testing for infectious agents such as human immunodeficiency virus (HIV), cytomegalovirus (CMV) and hepatitis viruses. The cord blood unit is checked to make sure it has enough blood-forming cells for a transplant. If there are too few cells, the cord blood unit may be used for research to improve the transplantation process for future patients, or it may be discarded. When testing has been completed, the blood is frozen and stored at a very low temperature, usually in liquid nitrogen, for future use. When needed for

a transplant, the cord blood unit can be shipped, often within a few days, to the transplant center, where it is thawed and infused into the patient. Some mothers elect to have their baby's cord blood stored privately. Such cord blood units are not available through the registries for general use.

## Conditioning

“Conditioning” is a term used for the therapy given to prepare patients for stem cell transplantation. Conditioning is usually a combination of two or more chemotherapy medications, either with or without radiation therapy. Remember, in an autologous transplant (when the patient's own stem cells are used for the transplantation), the stem cells are removed before the conditioning regimen begins.

Conditioning therapy is typically given over several days. Depending on the treatment plan, the number of days of conditioning will vary. Conditioning starts on a negative-numbered day (for example Day Minus 7 [Day –7, Day –6, etc ]). The day of transplant is counted as Day 0 (Day Zero). The days after the transplant are referred to as positive-numbered days (Day Plus One [Day +1, Day +2, etc]).

The conditioning regimen

- Treats the remaining cancer cells aggressively to make a recurrence of the cancer less likely
- Inactivates the patient's immune system to minimize the chance of stem cell graft rejection in an allogeneic transplant
- Enables donor immune cells to engraft and exert their potent antitumor effect in allogeneic transplant

High-dose conditioning regimens are used for autologous stem cell transplantations and for a large percentage of allogeneic stem cell transplantations. This chemotherapy is usually stronger than the chemotherapy received during earlier treatments. These high-dose regimens are particularly useful in treating patients who require stronger, more aggressive anticancer agents.

The particular conditioning that the patient receives is based on a number of factors, including

- Type of cancer
- Source of stem cells
- Previous treatments.

Certain conditioning regimens may cause difficult side effects, and members of the transplant team will discuss these with the patient before beginning the conditioning therapy. The chemotherapy will be given intravenously through the central venous catheter. During chemotherapy, the patient will receive intravenous

fluids for hydration and medications, such as anti nausea drugs, to ease uncomfortable symptoms. Patients who receive allogeneic stem cell transplants also start receiving immunosuppressant medication to prevent graft-versus-host disease.

Patients being prepared for a reduced-intensity allogeneic stem cell transplantation receive lower doses of chemotherapy drugs, either with or without radiation, in preparation for the transplant, compared with the dosages given to patients receiving a standard allogeneic stem cell transplant. Medications are also given to suppress the immune system. The goal of this approach is to suppress the immune system enough to allow the donor stem cells to take over and produce a new immune system that will fight the cancer.

**Radiation Therapy.** Radiation therapy given before transplantation is usually total body irradiation. Total body irradiation uses small doses of radiation delivered to the entire body and can destroy cancer cells throughout the body. Total body irradiation therapy is administered in several divided daily doses. These divided doses minimize side effects such as lung injury, nausea and vomiting. The radiation treatments are usually given 1 to 3 times a day over 2 to 4 days immediately before transplantation. Having radiation therapy feels like having an x-ray and it does not hurt. There may, however, be side effects after treatment.

An extra dose of radiation (a boost) may be given to certain areas of the body. The treatment depends on the disease. For example, some men who have leukemia or lymphoma may receive a “boost” or an extra dose of radiation to their groin area to kill cancer cells that may be hidden in the testicles.

**Rest.** Some patients have a day or two of rest between their conditioning regimen and their stem cell infusion. The rest period gives the chemotherapy time to leave the patient’s body so that when the patient receives the stem cells, there will be no trace of chemotherapy left in the body to harm the newly transplanted stem cells. Not all patients, however, have a day of rest between their conditioning regimen and transplantation.

## Stem Cell Infusion

On Day 0 (Zero), transplant day, the stem cells that were collected are infused into the patient’s bloodstream through the central venous catheter.

For patients receiving T-cell depleted allogeneic stem cell transplants, the T cells are removed from the stem cells before they are infused into the patient. Elimination of T cells from the graft may reduce the risk of GVHD. T-cell depletion, however, may lead to an increased risk of infections post transplant, or even graft rejection and relapse. For these reasons, T cells are depleted from the stem cell collection only in certain circumstances.

Infusing stem cells into the patient's vein is similar in many ways to administering a blood transfusion. For example

- Prior to the transfusion, the patient receives intravenous fluids and medications to help prevent a reaction and reduce side effects during the infusion.
- Infusing the stem cells usually takes several hours. Patients are checked frequently for signs of fever, chills, hives, a drop in blood pressure or shortness of breath. Often, patients experience no side effects from the infusion. If side effects do occur, they are treated; and then the infusion is completed.
- When the stem cells have been collected and then frozen for storage, side effects are more common. The side effects are caused by the preservative that is used to store the stem cells. They may include headache, nausea, flushing and shortness of breath.
- Patients who receive stem cells that have been frozen and preserved may notice a strong, garlic like taste in their mouths. Their urine and sweat may also have a garlic like smell. The smell is caused by the preservative used to store the stem cells. The smell will gradually fade over a few days.

## Immediate Post-Transplant Period

After the stem cells are infused, they will travel to the bone marrow and make new blood cells. This is called “engraftment.” Engraftment usually happens within the first 30 days after transplantation, but sometimes it can take longer. Engraftment means the new stem cells are working properly and starting to rebuild the immune system.

Engraftment marks the start of the recovery process. White blood cells are the first cells to engraft, followed by red blood cells and then platelets. The doctor will check the patient's blood counts every day to see if the patient's bone marrow has begun producing new blood cells. As engraftment occurs, the white blood cells, red blood cells and platelets will begin to increase in number.

**Side Effects of the Conditioning Regimen.** Prior to engraftment, blood counts will drop to their lowest levels, and the patient's immune system will not be effective. In addition to infections, the patient is also at risk for anemia (low red blood cell count), bleeding (low platelet count) and other concerns.

**Infections.** White blood cells, part of the immune system, fight infections. During the post-transplant period, patients are very vulnerable to infections because they have very low white blood cell counts (a condition called “neutropenia”). Additionally, patients who have undergone allogeneic stem cell transplantation receive intensive treatments to suppress the immune system to prevent graft-versus-host disease. These immunosuppressive treatments further increase the risk of infections.

The patient's healthcare team will try to prevent and treat any infections that develop. Many precautions are taken to reduce the patient's risk of infection. For example

- Patients receive broad-spectrum antibiotics, antiviral and antifungal agents to prevent infections.
- The cytomegalovirus (CMV) can cause serious complications and even death following transplantation. Cytomegalovirus is related to the viruses that cause chicken pox and infectious mononucleosis. Most adults in the United States have been exposed to CMV. Once infected, a person carries the virus in an inactive state for life. A healthy immune system keeps the virus from multiplying and causing any further illness. The virus, however, can become a serious problem for people with weakened immune systems. It is possible for the virus to become reactivated after a stem cell transplant and cause a serious infection in any organ of the body.

Doctors may administer antiviral drugs to patients who test positive for CMV to try to prevent reactivation of the virus after transplantation. The US Food and Drug Administration (FDA) approved **letermovir (Prevymis™)**, given by mouth or intravenous infusion, for prevention of cytomegalovirus (CMV) infection and disease in adults who may be susceptible to CMV infection after their stem cell transplant. Another approach is to give a patient regular blood tests after transplantation to check for early signs of CMV infection. If early detection finds traces of the virus, antiviral medication can be given to prevent it from spreading.

- Hand washing is very effective in reducing the spread of germs that cause infections. All visitors entering a patient's room should wash their hands.
- No visitors are allowed if they are sick. Patients should avoid close contact with anyone who has a cold, flu, chicken pox, measles or any other illness that can spread to the patient. Patients should also avoid contact with people who have had recent immunizations with live viruses.
- Plants and flowers should not be kept in the patient's room because they are potential sources of harmful microorganisms.
- After transplantation, patients should receive a low-microbial diet comprised of food that contains low numbers of potentially harmful microbes. Patients should avoid raw and undercooked meat and fish, non pasteurized dairy products, raw eggs, raw honey, and unwashed raw vegetables and fruit.
- Patients should continue to follow the recommendations mentioned above even after they are discharged from the hospital, because it takes time for the immune system to recover. They should speak to members of their treatment team for specific recommendations about an appropriate diet or ask for a referral to a dietitian.

LLS Information Specialists, at (800) 955-4572, will also schedule a free consultation with a registered dietitian with experience in oncology nutrition.

**Anemia.** Patients with low red blood cell counts may experience weakness, fatigue, and shortness of breath. Transfusions of red blood cells can ease symptoms until the bone marrow begins to produce sufficient numbers of red blood cells. In certain cases where there is a mismatch in blood type, this process can take several months.

**Thrombocytopenia.** Thrombocytopenia is a condition in which there is a lower-than-normal number of platelets in the blood. After transplantation, platelet counts are low. The low number of platelets may result in easy bruising and excessive bleeding from wounds or bleeding from mucous membranes such as the nose, mouth, skin and gastrointestinal tract. Patients receive platelet transfusions if their platelet counts are too low.

**Side Effects on Organs and Body Parts.** In addition to low blood counts, there are other short-term side effects associated with the conditioning regimen. The chemotherapy dosages used before transplantation are usually higher than the dosages used in standard chemotherapy, so the typical side effects of the conditioning regimen chemotherapy may be more intense, especially during the weeks after transplantation. It is important for patients to notify their doctor or nurse of any side effects so they can be treated. The following areas are especially sensitive to chemotherapy drugs and radiation therapy:

- **Gastrointestinal Tract.** Chemotherapy drugs can cause severe nausea and vomiting. Doctors often give anti nausea medication along with chemotherapy to try to prevent it. It is easier to prevent nausea and vomiting before it starts. Patients should inform their doctor or nurse how well the medicines are controlling the nausea and vomiting. If they are not working, the medicines may need to be changed. Patients may also experience diarrhea, intestinal cramps and rectal or anal ulceration.
- **Mouth.** Another serious side effect is oral mucositis (mouth sores). These painful mouth sores can prevent patients from eating and drinking. When needed, an agent such as the epidermal (skin type cells) growth factor palifermin (Kepivance®), given intravenously, can be used to prevent or minimize the effects of oral mucositis. Palifermin stimulates the cells that line the mouth and gastrointestinal tract to grow and develop.
- **Heart.** Some conditioning therapies can affect the heart. The effect may be temporary but it can sometimes be permanent. Although damage to the heart is very serious, it is a rare complication.
- **Lungs.** A reaction called “interstitial pneumonia” can occur as a result of infection or damage from intensive therapy. High doses of chemotherapy, especially when accompanied by total body irradiation therapy, can damage the cells in the lungs. Patients typically experience a dry non productive cough

or shortness of breath. This side effect can be very severe and prevent the efficient exchange of oxygen in the lungs. It may occur at any time—from a few days after high-dose chemotherapy to several months after treatment—and may even occur after a patient has returned home. It is important for patients who experience shortness of breath or a new cough after transplantation to bring this to the immediate attention of their doctor or nurse since interstitial pneumonia can be a serious or even fatal complication.

- **Skin.** Rashes may develop. Skin effects are evaluated and treated to help make patients more comfortable and to prevent serious complications.
- **Blood Vessels.** Leaky blood vessels may result from the accumulated injury caused by chemotherapy and radiation therapy. (Chemicals released as a result of the immune reactions to donor cells also contribute to this effect by damaging vessel walls.) Fluid escapes from the vessels and accumulates in the tissues, causing a condition called “edema.” In the lungs, fluid accumulation may cause congestion, poor exchange of oxygen and shortness of breath. Medications such as corticosteroids, which decrease inflammation, are sometimes used to manage this complication. Chemotherapy can sometimes damage the patient’s veins, leading to blood clots forming in the lower extremities. Many centers now employ the use of blood thinners to reduce the chance of clots forming. Being out of bed and walking can also help reduce the likelihood of the formation of blood clots. Diseases, such as myeloma, also put the patient at higher risk of blood vessel issues.
- **Liver.** High-dose chemotherapy can result in damage to the liver. The blood vessels that lead into and pass through the liver are prone to blockage after transplantation. Venous-occlusive disease (VOD) also known as “sinusoidal obstructive syndrome” causes the blood vessels that carry blood through the liver to become blocked. Symptoms of VOD include jaundice (yellowing of the skin and eyes), weight gain from fluid retention and a painfully enlarged liver. VOD varies in severity. Sometimes it is mild and resolves quickly. Other times, VOD can be more serious and even life threatening. Treatment of VOD may include red blood cell transfusions, diuretics and drug therapy. The Food and Drug Administration (FDA) approved defibrotide sodium (Defitelio®) for the treatment of adult and pediatric patients with VOD who have renal or pulmonary dysfunction following stem cell transplantation. Medications and GVHD can also cause liver dysfunction or damage after the transplantation, and the patient’s liver function tests will be monitored periodically.
- **Hair.** Hair loss occurs with many conditioning regimens (chemotherapy). It is generally temporary, and hair growth resumes when the drugs are discontinued. As hair grows back, it is important to keep the scalp protected from the sun, heat and cold. The new hair may be a different color or texture and it may be thinner than it was before the transplant.
- **Eyes.** May become jaundiced (yellowed) or develop cataracts.

# Graft-Versus-Host Disease

Graft-versus-host disease (GVHD) is a potentially serious complication of standard allogeneic and reduced-intensity allogeneic stem cell transplantations. GVHD occurs when the donor's T cells (the graft) view the patient's healthy cells (the host) as foreign, and attack and damage them. A close HLA match between the donor and patient helps to lower the risk of GVHD, but it does not eliminate it. Graft-versus-host disease can be mild, moderate or severe. In some cases, it can be life-threatening.

Unless the patient's donor is an identical twin, a patient receiving an allogeneic stem cell transplant will receive some type of GVHD prevention. This may include removing T cells from the donor graft and/or giving medications to suppress the T cells in the graft so that they do not attack the patient's cells.

There is no standard regimen for the prevention of GVHD, and different combinations of medications are given at different institutions. Some common medications that are given to prevent GVHD include

- **Methotrexate (Trexall®)**
- **Cyclosporine**
- **Tacrolimus (Prograf®)**
- **Mycophenolate mofetil (CellCept®)**
- **Sirolimus (Rapamune®)**
- **Corticosteroids (methylprednisolone or prednisone)**
- **Antithymocyte globulin (ATG)**
- **Alemtuzumab (Campath®)**
- **Cyclophosphamide (Cytoxan®).**

**Types of Graft-Versus-Host Disease.** There are two main categories of GVHD: acute graft-versus-host disease and chronic graft-versus-host disease. Each type affects different organs and tissues and has different signs and symptoms. Patients may develop one type, both types, or neither type.

**Acute GVHD.** This usually develops within the first 100 days after transplantation, but it can occur later. Acute GVHD can affect the skin, the gastrointestinal tract or the liver. Symptoms may include

- A rash, with burning and redness of the skin. This may erupt on the patient's palms or the soles of the feet, and often involves the trunk and other extremities as well. The skin may blister, and in severe cases of GVHD, the exposed surface of the skin may flake off.
- Nausea, vomiting, abdominal cramps, loss of appetite and diarrhea indicate involvement of the gastrointestinal tract.

- Jaundice (yellowing of the skin or eyes) may indicate that GVHD has injured the liver. Abnormalities of liver function would be noticed on blood test results.

Many patients who develop acute GVHD are successfully treated with increased immunosuppression in the form of corticosteroids (medicines such as prednisone, methylprednisolone, dexamethasone, beclomethasone and budesonide).

**Chronic GVHD.** This is a syndrome that may involve a single organ or several organs. It is one of the leading causes of medical problems and death after an allogeneic stem cell transplantation. Symptoms may include

**Mouth.** Patients with GVHD may experience

- A very dry mouth
- Sensitivity to hot, cold, spicy and acidic foods; mint (eg, mint flavored toothpaste); carbonated drinks
- Painful mouth ulcers that may extend down the throat
- Difficulty eating
- Gum disease and tooth decay.

**Skin.** Patients with GVHD may have

- A rash
- Dry, tight, itchy skin
- Thickening and tightening of the skin, which may result in restriction of joint movement
- A change in skin color
- Intolerance to temperature changes due to damaged sweat glands.

**Nails.** Patients with GVHD may experience

- Changes in nail texture
- Hard, brittle nails
- Nail loss.

**Scalp and Body Hair.** Patients with GVHD may notice

- Loss of hair on the head
- Premature gray hair
- Loss of body hair.

**Gastrointestinal Tract.** Patients with GVHD may experience

- Loss of appetite
- Unexplained weight loss
- Nausea
- Vomiting
- Diarrhea
- Stomach pain.

**Lungs.** Patients with GVHD may suffer from

- Shortness of breath and difficulty breathing
- A persistent, chronic cough that does not go away
- Wheezing.

**Liver.** A patient with GVHD may have

- Abdominal swelling
- Jaundice (yellow discoloration of the skin and/or eyes)
- Abnormal liver function test results.

**Muscles and Joints.** Side effects of GVHD may include

- Muscle weakness and cramps
- Joint stiffness causing difficult full extension of fingers, wrists, elbows, knees, ankles.

**Genitalia.** Chronic GVHD can have the following effects on the genitalia of women and men:

- Female
  - Vaginal dryness, itching and pain
  - Vaginal ulcerations and scarring
  - Narrowing of the vagina
  - Difficult /painful intercourse
- Male
  - Narrowing and/or scarring of the urethra
  - Itching or scarring on the penis and scrotum
  - Irritation of the penis.

See *Sexual Health* on page 39.

Patients with mild symptoms of chronic GVHD, especially if the symptoms are limited to a single organ or site, can often be treated with close observation or with local/topical therapies. For example, mild cases of chronic skin GVHD may be treated with topical steroid ointments and cases of chronic ocular (eye) GVHD may be treated with immunosuppressive eye drops.

Patients with more severe symptoms or multi organ involvement chronic GVHD typically require “systemic” treatment, which travels through the bloodstream and reaches cells throughout the entire body. Prednisone is the standard first-line therapy for chronic GVHD. For patients who do not respond to prednisone or other steroid treatments, the Food and Drug Administration (FDA) has approved the drug ibrutinib (Imbruvica®) as a second-line treatment for adult patients with chronic GVHD after one or more other treatments have failed. Other combinations of immune suppressive drugs may be used to control the symptoms of GVHD.

Patients must be aware of the warning signs of GVHD and should call their doctors immediately if they have any symptoms. Early detection and treatment may help limit the severity of the disease.

**For more information, see the free LLS booklet, *Graft-Versus-Host Disease*.**

## Graft Failure

Graft failure occurs when the transplanted stem cells (the graft) fail to move into the bone marrow and make new blood cells. Graft failure is extremely rare in autologous stem cell transplantation. In allogeneic stem cell transplantation, graft failure is more common when the patient and donor are not well matched and when the patient receives T cell depleted transplants. It can also occur in patients who receive a graft that has a low number of stem cells, such as a single umbilical cord unit.

The most common treatment for graft failure is a second transplant, either using stem cells from the same donor or from a different donor. Other treatment options may include donor lymphocyte infusion or treatment within the setting of a clinical trial.

## Post-Transplant Lymphoproliferative Disorders

Post-transplant lymphoproliferative disorders (PTLDs) comprise a group of rare disorders that cause out-of-control growth of lymphocytes after allogeneic stem cell transplantation. Most PTLDs are caused by the Epstein Bar virus (EBV), a type of herpes virus. Generally, it occurs within the first few months after transplantation.

There is no standard treatment for PTLDs. Treatment for a PTLD depends on its subtype; however, reduction of immunosuppression medication is often the initial treatment approach for all subtypes. Reducing the dosage of immunosuppression

drugs may allow the patient's own immune system to fight the EBV. Other treatment options include using the drug rituximab (Rituxan®) to kill the B cells, lymphocyte transfusions to boost the immune system, anti viral drugs to treat EBV infection, infusion of cytotoxic T lymphocytes and a clinical trial. A treatment option for patients with a PTLD that is localized in one area of the body is surgical removal of the lymph node or tumor. Combination chemotherapy is a treatment option for patients with aggressive disease.

**For more information, see the free LLS booklet, *Post-Transplant Lymphoproliferative Disorder*.**

## **Early Recovery (From discharge up to about one year)**

Once engraftment has occurred and early side effects or complications have been resolved, members of the transplant team will begin working on discharging the patient. A patient is ready for discharge when

- Engraftment has occurred and the patient is producing sufficient numbers of healthy white blood cells, red blood cells and platelets.
- There is no indication of infection.
- The patient can tolerate medications.
- The patient is able to eat and drink to get sufficient fluids and nourishment.
- There are no severe treatment complications.
- The patient is medically stable and physically able to function outside the hospital.

Although the patient's blood counts may be returning to the normal range, the immune system is still very immature. The patient or his or her caregivers should call the doctor or nurse immediately if there are any symptoms of infection, including

- Fever or chills
- Coughing, sneezing, runny nose, sore throat or shortness of breath
- Nausea, vomiting or diarrhea
- Blood in the urine or pain during urination
- Rash or cold sores.

Follow-up care is extremely important. Visits by the patient to the outpatient clinic and the doctor's office are crucial, as are home care visits from professional healthcare personnel. Initially, doctor visits may be frequent, and allogeneic transplant patients may need follow-up visits several times per week. If all is going as anticipated, the central venous catheter can be removed and the frequency of follow-up visits can gradually be decreased. At these follow-up visits to the

doctor's office or the outpatient clinic, the doctor will order blood tests to check blood counts, electrolyte levels, and liver and kidney function. At some visits, bone marrow aspirations and biopsies will be done to check blood cell growth in the bone marrow.

In general, there is a shorter recovery period after autologous stem cell transplantation than after allogeneic stem cell transplantation. In an autologous transplant, it often takes the immune system 3 to 12 months to recover. For an allogeneic transplant, it often takes at least 6 to 12 months to recover nearly normal blood cell levels and immune cell function. Immune recovery can take longer if the patient has GVHD and requires additional GVHD therapy.

The recovery time a stem cell transplant recipient needs before he or she feels "normal" or returns to work or school is different for each person. For some patients, recovery after stem cell transplantation can be very difficult. It depends on a patient's side-effects and complications.

During the recovery period, the stem cells are creating new blood cells, and the cells in the mouth, stomach, intestines, hair, and muscles are regrowing. The body is exerting energy to make these new cells, and fatigue and weakness are not unusual. For most people, the first few months to one year after transplant remain a time of recovery. As patients regain more strength, they may begin slowly resuming daily activities.

**Nutrition.** In the recovery phase after stem cell transplantation, it is important to eat a well-balanced diet. After a patient undergoes chemotherapy and radiation treatment, his or her cells need to recover and repair themselves. Protein from food provides energy for the body and the building blocks for that repair. If a patient does not get the necessary number of calories and enough protein, the body may take the energy it needs from the muscles, causing further weakness and fatigue. Patients taking corticosteroids may have issues with sugar control and should limit their carbohydrate consumption. Electrolytes, which are important minerals in blood and other body fluids, can be obtained from certain foods and liquids such as Gatorade. Consultation with a nutritionist is important if a patient's food and drink intake is lacking or improper.

**Reach out to LLS Information Specialists, at (800) 955-4572, to schedule a free consultation with a registered dietitian. See the free LLS booklet *Food and Nutrition Facts*.**

**Exercise.** Most people find it takes time to regain their strength. It may be helpful to follow a regular exercise plan. A growing body of evidence suggests that physical activities, such as walking, riding a stationary bicycle, yoga, tai chi, swimming or water exercises, and strength training, may alleviate fatigue and increase energy levels. Patients should consult with their doctors before starting an exercise program. The doctor may refer patients to a physical therapist for an evaluation and an exercise plan.

**Returning to Work and School.** Typically, the earliest a patient can return to school or work is about 4 months after an autologous transplant and 1 year after an allogeneic transplant. This time frame can vary from person to person and depends on the patient's health and type of work. If the work is either physically demanding or if it puts the patient at risk of infection, he or she may need to wait longer before returning to work. Returning to work or school gradually maybe a good plan. Patients may want to return to part-time work at first and then gradually increase their hours.

Making the transition back to school or work can be difficult. Some patients do not have the same stamina they had before transplantation and cannot keep up their former pace. Patients should talk to members of their transplant team about going back to school or work.

**Sexual Health.** After transplantation, patients often have difficulty engaging in sexual activity. Many of these difficulties are due to the physical effects of chemotherapy and radiation treatments. Common concerns include fatigue, loss of sexual desire, vaginal dryness, and getting and maintaining an erection. These concerns are often temporary and will likely resolve over time. However, intervention may be needed to make patients feel more comfortable. While some patients may feel uncomfortable discussing these matters, it is important for patients and their partners to have answers to all their questions. Patients are encouraged to find someone on their transplant team with whom they feel comfortable discussing their concerns. There are medical and psychological interventions that are available to help patients.

Once patients feel ready to resume sexual activity, they need to take the following precautions to protect themselves:

- Avoid sexual activity that involves penetration or contact with mucous membranes until their white blood cell and platelet counts have recovered. This includes vaginal, oral and anal sex.
- Use latex condoms each time there is sexual activity even after white blood cell and platelet counts have recovered.
- Use a barrier device (condoms or dental dams) any time a partner's vaginal secretions or semen could enter the mouth.
- Avoid sex that involves contact with mucous membranes if a partner has a genital infection.

**For more information, see the free LLS booklet, *Sexuality and Intimacy Facts*.**

## Survivorship *(One year after transplant and beyond)*

Long-term follow-up care is important after both autologous and allogeneic transplantation. Even after cancer treatment has ended, patients need to continue to schedule appointments with their cancer team in addition to having routine check-ups and health screenings. If a patient is unable to return to the transplant center for yearly follow-up visits, it is important that his or her local oncologist is made aware of all the follow-up recommendations related to various organ systems. Long-term follow-up appointments and tests typically continue for many years.

**Immunizations.** After transplantation, patients lose the protection from vaccines that they had received as children. All transplant patients need to receive childhood vaccines once their immune systems have recovered. Autologous transplant recipients typically receive inactivated vaccines starting 6 months after transplant and live vaccines 24 months after transplant. For patients who have undergone allogeneic transplants, many doctors wait until 12 months after transplantation to start vaccinating patients or until patients are off immunosuppressive therapy. After that, they should follow their transplant doctor's recommended schedule.

**Long-Term Complications.** Many transplant recipients experience the following long-term side effects even years after transplantation:

- There is still the possibility of organ complications after transplant. There may be damage to the liver, kidneys, liver, heart or lungs. Blood tests and pulmonary function tests will be done to monitor the patient's health. Stem cell transplant recipients have a higher risk of cardiac problems after transplant. Electrocardiograms and echocardiograms may be done to monitor new symptoms.
- The endocrine system, which makes hormones that control growth, sexual development, sleep, hunger and metabolism may be affected by the transplant. After transplantation, hormone levels—including thyroid levels—may not return to normal. Some patients develop hypothyroidism, an underactive thyroid gland, after radiation therapy. If a patient develops hypothyroidism, the patient will receive oral thyroid medication.
  - Children may have a slowed growth rate and may require growth hormone treatments and replacement of other hormones.
  - In young patients, puberty may be delayed and hormonal therapy required.
- Long-term survivors of stem cell transplants are at risk for bone loss and subsequent osteoporosis. To reduce bone fracture risk, patients may be advised to take adequate amounts of calcium and vitamin D. Patients at high risk for bone loss may be prescribed medications used for the prevention or treatment of osteoporosis.

- Patients who have received radiation therapy or high-dose steroids may develop cataracts. After transplantation, patients should have their eyes regularly examined. Cataracts cause the lenses of the eyes to become cloudy, and they can occur in either one or both eyes. Symptoms include blurred, cloudy, or double vision; sensitivity to light; and difficulty seeing at night. Without treatment, cataracts can lead to blindness.
- Chemotherapy and radiation therapy may lead to infertility. Hormone replacement is usually not necessary for men. For women, estrogen and progesterone replacement therapy may be needed. When pregnancy is not desired, the use of contraception is recommended because it cannot be predicted when or even if fertility will return.
- A potential late complication of stem cell transplantation includes chronic GVHD, which can affect any part of the body. Severe chronic GVHD can negatively affect a patient's health and quality of life. Patients should be aware of the warning signs of chronic GVHD and should call their doctors immediately if they have any symptoms. Early detection and treatment may help limit the severity of the disease.
- Feelings of depression and anxiety are common during this time. Patients should seek medical advice if their mood does not improve over time—for example, if the patient feels depressed every day for a 2 week period. It may be helpful for the patient to get a referral to a therapist or counselor who has experience treating people who are recovering from life-threatening illnesses.
- Sometimes after transplantation, the cancer may return (relapse). Learning of a relapse can be distressing and overwhelming, but it is important to remember that there are often other treatment options available. These may include a donor lymphocyte infusion, chemotherapy, a second transplant, immunotherapy, or a clinical trial.
- Secondary cancer is a new, unrelated cancer that occurs after successful treatment of the first cancer. Stem cell transplant recipients have a higher risk of developing a secondary cancer. Therefore, lifelong cancer screenings are important for transplant patients.

**See the free LLS booklets, *Fertility, Long-Term and Late Effects of Treatment in Childhood Leukemia or Lymphoma Facts* and *Long-Term and Late Effects of Treatment in Adults Facts* for more information about treatment effects and follow-up care.**

Post-transplant care guidelines have been developed for patients (see *Other Transplant Organizations* on page 57) and doctors (see *References* on page 58). It is important for patients to discuss any symptoms they are experiencing with members of their healthcare team.

# Clinical Trials

New approaches to treatment in clinical trials, many of which are being supported by LLS research programs, hold the promise of improving the rate of remission and the cure rate for patients with blood cancers.

**Clinical Trials.** Every new drug or treatment regimen goes through a series of studies called “clinical trials” before it becomes part of standard therapy. Clinical trials are carefully designed and reviewed by expert clinicians and researchers to ensure as much safety and scientific accuracy as possible. Participation in a carefully conducted clinical trial may be the best available therapy for some patients. Patient participation in past clinical trials has resulted in the therapies we have today.

**LLS Information Specialists, at (800) 955-4572, can offer guidance on how patients can work with their doctors to determine if a specific clinical trial is an appropriate treatment option. Information Specialists will conduct individualized clinical-trial searches for patients, family members and healthcare professionals. When appropriate, personalized clinical-trial navigation by trained nurses is also available.**

**Research Approaches.** A number of approaches are under study in clinical trials focusing on stem cell transplantation treatment. Studies are under way to find less toxic conditioning regimens to allow more older patients and those with comorbidities to have access to stem cell procedures, more ways to expand the pool of donors, and new drugs to reduce the risk and treat GVHD. We encourage patients to contact our Information Specialists and visit [www.LLS.org](http://www.LLS.org) for more information about specific treatments under study in clinical trials.

# Normal Blood and Marrow

**Blood.** Blood is the liquid that flows through a person’s arteries and veins. It carries oxygen and nutrients to living cells and carries away the cells’ waste products. It also contains immune cells to fight infections and platelets that can stop bleeding in damaged blood vessels.

Blood is composed of plasma and blood cells.

**Plasma.** Plasma is largely made up of water in which many chemicals are dissolved. These chemicals each have a special role. They include

- Proteins
  - Albumin, the most common blood protein
  - Blood-clotting proteins (coagulation factors) that are made by the liver

- Erythropoietin, a protein made by the kidneys that stimulates red blood cell production
- Immunoglobulins, proteins that help the body to fight infection
- Hormones, such as insulin and corticosteroids
- Minerals, such as iron and magnesium
- Vitamins, such as folate and vitamin B<sub>12</sub>
- Electrolytes, such as calcium, potassium and sodium.

**Blood Cells.** There are three types of blood cells suspended in the plasma. They are

- Red blood cells (the cells that carry oxygen), which
  - Make up a little less than half of the body's total blood volume
  - Are filled with hemoglobin, a protein that picks up oxygen from the lungs and delivers it to the cells throughout the body
  - Hemoglobin then picks up carbon dioxide from the cells and delivers it to the lungs where it is removed when a person exhales.
- Platelets
  - Are fragments of cells (one-tenth the size of red blood cells)
  - Help stop bleeding from an injury
  - When a person has a cut and blood vessels are torn, platelets stick to the tear, clump together and plug up the bleeding site
- White blood cells (cells that fight infections, an important part of the immune system). There are several types of white blood cells, including
  - Neutrophils. Called "phagocytes" (eating cells); help fight infection by ingesting microorganisms and releasing enzymes that kill the microorganisms. It is a type of granulocyte, a white blood cell that has small particles.
  - Eosinophils. Play an important role in the body's response to allergic reactions and parasite infection
  - Basophils. Fight off allergic reactions and asthma
  - Monocytes. Phagocytes that can leave the bloodstream and enter tissues to attack invading organisms and fight off infection by surrounding and killing microorganisms, ingesting foreign material and removing dead cells

- Lymphocytes. Found mostly in the lymph nodes, spleen and lymphatic channels; three major types of lymphocytes are
  - T lymphocytes (T cells)
  - B lymphocytes (B cells)
  - Natural killer (NK) cells.

New red blood cells, platelets and most white blood cells are formed in the bone marrow, a spongy tissue found in the central cavity of bones. The creation of new blood cells is controlled by the body's needs. The human body generates billions of new blood cells every day to replace old and worn-out cells. Certain events also may prompt the body to produce additional blood cells. For example, the bone marrow produces and releases extra white blood cells in response to an infection.

Red blood cells, white blood cells and platelets vary in appearance and function, but they all originate from a single type of unspecialized cell called a "hematopoietic stem cell." Hematopoietic (blood-forming) stem cells are found in the bone marrow of the femurs (thigh bones), hips, vertebrae (back bones) and the ribs. An unspecialized hematopoietic stem cell can give rise to specialized cells that have specific functions. For example, a hematopoietic stem cell can give rise to a red blood cell that carries oxygen throughout the body, or it can give rise to a neutrophil or another type of white blood cell that helps to fight infections. The process by which an immature cell becomes a mature cell with a specific function is called "differentiation."

The process of creating new blood cells through differentiation is called "hematopoiesis" (see **Figure 5** on page 45). When a stem cell divides, each "daughter" cell has the potential to either remain a stem cell or to become a specialized cell such as a red blood cell, a white blood cell or a platelet. For those cells "committed" to specialize, the stem cell generates an intermediate cell. The intermediate cell is called a "precursor" or "progenitor" cell. While the stem cell remains in an immature, unspecialized state, the progenitor cell divides and undergoes multiple stages of development, becoming more specialized at each stage, until it becomes a particular type of mature blood cell.

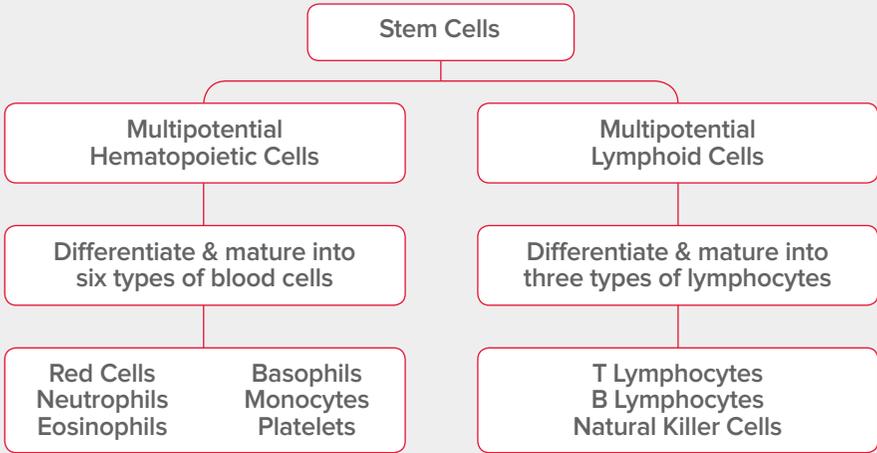
The hematopoietic stem cell can give rise to lymphoid stem cells and myeloid stem cells. The lymphoid stem cells create lymphoid progenitor cells. Different types of progenitor or precursor cells develop into different types of mature blood cells. Through the process of differentiation, lymphoid progenitor or precursor cells can mature into T cells, B cells, plasma, or NK cells.

Myeloid stem cells create myeloid progenitor cells. These precursor or progenitor cells develop into mature blood cells including red blood cells, platelets and certain types of white blood cells (eosinophils, basophils, neutrophils and monocytes.) For example, a myeloid progenitor cell will go through various

stages of development to become a neutrophil as follows: myeloid progenitor → promyelocyte → myelocyte → metamyelocyte → band → neutrophil.

In healthy people, stem cells in the bone marrow produce new blood cells continuously. Once the blood cells have matured, they leave the bone marrow and enter the bloodstream.

### Blood Cell & Lymphocyte Development



**Figure 5.** Stem cells develop into blood cells (hematopoiesis) and lymphocytic cells.

# Resources and Information

LLS offers free information and services to patients and families affected by blood cancers. This section of the booklet lists various resources that can be helpful to you. Use this information to learn more, to ask questions, and to make the most of your healthcare team members' knowledge and skills.

## For Help and Information

**Consult with an Information Specialist.** Information Specialists are master's level oncology social workers, nurses and health educators. They offer up-to-date disease and treatment information. Language services are available. For more information, please

- Call: (800) 955-4572 (Monday through Friday, from 9 am to 9 pm EST)
- Email: [infocenter@LLS.org](mailto:infocenter@LLS.org)
- Live chat: [www.LLS.org/InformationSpecialists](http://www.LLS.org/InformationSpecialists)
- Visit: [www.LLS.org/InformationSpecialists](http://www.LLS.org/InformationSpecialists)

**Free Information Booklets.** LLS offers free education and support booklets that can be either read online or ordered. For more information, please visit [www.LLS.org/booklets](http://www.LLS.org/booklets).

Some of the free LLS booklets include

*Blood Transfusion*

*Choosing a Blood Cancer Specialist or Treatment Center*

*Fertility Facts*

*Long-Term and Late Effects of Treatment for Childhood Leukemia*

*or Lymphoma Facts*

*Long-Term and Late Effects of Treatment in Adults Facts*

*Understanding Clinical Trials for Blood Cancers*

*Understanding Lab and Imaging Tests*

*Understanding Side Effects of Drug Therapy.*

**Co-Pay Assistance Program.** LLS offers insurance premium and medication co-pay assistance for eligible patients. For more information, please

- Call: (877) 557-2672
- Visit: [www.LLS.org/copay](http://www.LLS.org/copay)

**One-on-One Nutrition Consultations.** Access free one-on-one nutrition consultations by a registered dietitian with experience in oncology nutrition. The dietitian can provide assistance with healthy eating strategies, side effect management, and survivorship nutrition as well as provide additional nutrition resources. For more information, please visit [www.LLS.org/nutrition](http://www.LLS.org/nutrition)

**Telephone/Web Education Programs.** LLS offers free telephone/Web and video education programs for patients, caregivers and healthcare professionals. For more information, please visit [www.LLS.org/programs](http://www.LLS.org/programs)

**Podcast.** Listen in as experts and patients guide listeners in understanding diagnosis and treatment, and suggest resources available to blood cancer patients. *The Bloodline with LLS* is here to remind you that after a diagnosis comes hope. For more information and to subscribe, visit [www.LLS.org/TheBloodline](http://www.LLS.org/TheBloodline)

**Suggested Reading.** A list of books that are recommended for patients, caregivers, children and teens. To find out more, visit [www.LLS.org/SuggestedReading](http://www.LLS.org/SuggestedReading)

**Continuing Education.** LLS offers free continuing education programs for healthcare professionals. For more information, please visit [www.LLS.org/professionaled](http://www.LLS.org/professionaled)

## **Community Resources and Networking**

**LLS Community.** The one-stop virtual meeting place for talking with other patients and receiving the latest blood cancer resources and information. Share your experiences with other patients and caregivers and get personalized support from trained LLS staff. To join, visit [www.LLS.org/community](http://www.LLS.org/community)

**Weekly Online Chats.** Moderated online chats can provide support and help cancer patients reach out and share information. For more information, please visit [www.LLS.org/chat](http://www.LLS.org/chat)

**LLS Chapters.** LLS offers community support and services in the United States and Canada including the *Patti Robinson Kaufmann First Connection Program* (a peer-to-peer support program), in-person support groups, and other great resources. For more information about these programs or to contact your chapter, please

- Call: (800) 955-4572
- Visit: [www.LLS.org/chapterfind](http://www.LLS.org/chapterfind)

**Other Helpful Organizations.** LLS offers an extensive list of resources for patients and families. There are resources that provide help with financial assistance, counseling, transportation, patient care and other needs. For more information, please visit [www.LLS.org/ResourceDirectory](http://www.LLS.org/ResourceDirectory).

**Clinical Trials (Research Studies).** New treatments for patients are under way. Patients can learn about clinical trials and how to access them. For more information, please call (800) 955-4572 to speak with an LLS Information Specialist who can help conduct clinical-trial searches. When appropriate, personalized clinical-trial navigation by trained nurses is also available.

**Advocacy.** The LLS Office of Public Policy (OPP) engages volunteers in advocating for policies and laws that encourage the development of new treatments and improve access to quality medical care. For more information, please

- Call: (800) 955-4572
- Visit: [www.LLS.org/advocacy](http://www.LLS.org/advocacy)

### **Additional Help for Specific Populations**

**Información en Español (LLS information in Spanish).** For more information, please visit [www.LLS.org/especialistas](http://www.LLS.org/especialistas)

**Language Services.** Let a member of your healthcare team know if you need a language interpreter or some other resource, such as a sign language interpreter. Often, these services are free.

**Information for Veterans.** Veterans who were exposed to Agent Orange while serving in Vietnam may be able to get help from the United States Department of Veterans Affairs. For more information please

- Call: the United States Department of Veterans Affairs at (800) 749-8387
- Visit: [www.publichealth.va.gov/exposures/agentorange](http://www.publichealth.va.gov/exposures/agentorange)

**World Trade Center (WTC) Survivors.** People involved in the aftermath of the 9/11 attacks and subsequently diagnosed with a blood cancer may be eligible for help from the World Trade Center (WTC) Health Program. People eligible for help include

- Responders
- Workers and volunteers who helped with rescue, recovery and cleanup at the WTC-related sites in New York City (NYC)
- Survivors who were in the NYC disaster area, lived, worked or were in school in the area
- Responders to the Pentagon and the Shanksville, PA crashes.

For more information, please

- Call: WTC Health Program at (888) 982-4748
- Visit: [www.cdc.gov/wtc/faq.html](http://www.cdc.gov/wtc/faq.html)

**People Suffering from Depression.** Treating depression has benefits for cancer patients. Seek medical advice if your mood does not improve over time—for example, if you feel depressed every day for a 2-week period. For more information, please

- Call: National Institute of Mental Health (NIMH) at (866) 615-6464
- Visit: NIMH at [www.nimh.nih.gov](http://www.nimh.nih.gov). Enter “depression” in the search box.

**Feedback.** To give suggestions about this booklet, visit [www.LLS.org/PublicationFeedback](http://www.LLS.org/PublicationFeedback).

## Health Terms

**Allogeneic Stem Cell Transplantation.** A treatment that uses donor stem cells to restore a patient's bone marrow and blood cells. First, the patient is given conditioning therapy (high-dose chemotherapy or high-dose chemotherapy with total body radiation) to treat the blood cancer and to "turn off" the patient's immune system so that the donor stem cells will not be rejected. See also Reduced-Intensity Allogeneic Transplantation.

**Anemia.** A decrease in the number of red blood cells and, therefore, the hemoglobin concentration of the blood. This results in diminished ability of the blood to carry oxygen. If severe, anemia can cause a pale complexion, weakness, fatigue and shortness of breath on exertion.

**Antigen.** Any substance that causes the body to make an immune response against that substance. Antigens include toxins, chemicals, bacteria, viruses, or other substances that come from outside the body.

**Apheresis.** The process of removing certain components of a donor's blood and separating out various parts of blood into plasma and various types of cells including white blood cells, red blood cells, and platelets. The term encompasses returning the unneeded parts to the donor. This procedure is also used to remove circulating blood stem cells, which can be frozen, stored and used later for transplantation instead of bone marrow stem cells.

**Autologous Stem Cell Transplantation.** A procedure in which stem cells are removed from a cancer patient, stored, and then given back to the patient after the patient undergoes intensive chemotherapy with or without radiation therapy.

**Basophil.** A type of white blood cell that fights against certain allergic reactions.

**B Lymphocyte.** A specialized white cell that produces antibodies in response to any foreign substance, and especially to bacteria, viruses and fungi. There are three types of lymphocytes, which are a vital part of the immune system and are important in defense against infection. Also called "B cell."

**Bone Marrow.** The spongy tissue in the hollow central cavity of the bones that is the site of blood cell formation. After puberty, the marrow in the spine, ribs, breastbone, hips, shoulders and skull is most active in blood cell formation. In adults, the bones of the hands, feet, legs and arms do not contain blood-forming marrow because in these sites the marrow is filled with fat cells.

**Central Venous Catheter (CVC).** A central venous access device used to take blood samples and to administer therapies, medications, and other treatments to patients directly into a vein (intravenously). A thin tube is inserted and guided into a large vein, usually below the collarbone. A central venous catheter may stay in place for weeks or months to avoid the need for repeated needle-sticks. Also known as a “central line”: the peripherally inserted central venous catheter (PICC or PIC Line) and the implantable port are the two most common central lines.

**Chemotherapy.** The use of chemicals (drugs or medications) to stop the growth of cancer cells by either killing the cancer cells or by stopping them from dividing.

**Comorbidity.** The condition of having two or more diseases at the same time.

**Conditioning Treatment.** A process that usually includes chemotherapy either with or without radiation therapy that is used prior to autologous or allogeneic transplantation to prepare a patient’s body for stem cell transplantation.

**Cord Blood Stem Cells.** Stem cells that are present in blood that is drained from the placenta and umbilical cord. These stem cells can be infused into a patient’s bloodstream to replace damaged or diseased stem cells.

**Cryopreservation.** A method of freezing and storing cells, tissues or organs to save them for future use.

**Differentiation.** See Hematopoiesis.

**Electrolytes.** Electrolytes are minerals in the blood and other bodily fluids that carry an electric charge. Common electrolytes include calcium, chloride, magnesium, phosphorus, potassium and sodium. They can be acids, bases, or salts. The concentration of electrolytes in the bloodstream can be measured by different blood tests. Electrolytes affect body functions in many ways, including the amount of water in the body, the acidity of the blood (pH), muscle function and other important processes. The body loses electrolytes through sweating, and these must be replaced with electrolyte-containing fluid (generally by mouth [drinks] and sometimes intravenously [IV solutions]). Note that water does not contain electrolytes.

**Engraftment.** The process in which transplanted donor stem cells migrate to the recipient’s bone marrow where they produce blood cells of all types.

**Eosinophil.** A type of white blood cell that participates in allergic reactions and helps fight certain parasitic infections.

**Graft-Versus-Host Disease (GVHD).** A condition caused when stem cells from a donor (the graft) attack the healthy tissue of the transplant patient (the host). The principal sites of injury to the patient are the skin, the liver and the gastrointestinal tract.

**Graft-Versus-Tumor (GVT) Effect.** An immune response in which transplanted donor's T lymphocytes (the graft) recognize and attack the malignant cells of the transplant recipient (the host). This response can occur only in allogeneic stem cell transplantation.

**Granulocyte.** A type of white cell that has a large number of prominent granules in the cell body. Neutrophils, eosinophils and basophils are types of granulocytes.

**Growth Factor.** A chemical used to stimulate the production of neutrophils and shorten the period of low neutrophil counts in the blood after chemotherapy. Granulocyte-colony stimulating factor (G-CSF) and granulocyte-macrophage colony-stimulating factor (GM-CSF) are examples of growth factors that are made commercially. GM-CSF can also stimulate monocytes.

**Haploidentical Stem Cell Transplantation.** A haploidentical transplant is a type of allogeneic stem cell transplantation that uses healthy, blood-forming cells from a half-matched donor to replace the unhealthy ones. The donor is typically a family member. Parents are always half-match donors for their children, and siblings have a 50 percent chance of being a half-match donor for each other.

**Hematologist.** A doctor who specializes in the treatment of blood cell diseases. This person is either a specialist who treats adults or a pediatric hematologist who treats children.

**Hematopathologist.** See Pathologist.

**Hematopoiesis.** The process of blood cell development in the bone marrow. The most undeveloped cells in the marrow are stem cells. They start the process of blood cell development. The stem cells begin to develop into young or immature blood cells such as red blood cells or white blood cells of various types. This process is called "differentiation." The young or immature blood cells then further develop into fully functional blood cells. This process is called "maturation."

The mature cells leave the marrow, enter the bloodstream and circulate throughout the body. Hematopoiesis is a continuous process that is normally active throughout life. The reason for this activity is that most blood

cells live for short periods and must be steadily replaced. Red blood cells die in 4 months, platelets in 10 days and most neutrophils in 1 to 3 days. About 200 billion blood cells are made each day. When the bone marrow is invaded with cancer cells, the constant demand for new blood cells cannot be met, resulting in a severe deficiency in blood cell counts.

**Hematopoietic Stem Cell.** See Stem Cells.

**HLA(s).** The abbreviation for “human leukocyte-associated antigen(s).” These antigens are proteins on the surface of most tissue cells and they give an individual his or her unique tissue type. Human leukocyte-associated antigens play an important part in the body’s immune response to foreign substances. Human leukocyte-associated antigens factors are inherited from mother and father, and the greatest chance of having the same HLA type is between siblings. On average, one in four siblings is expected to share the same HLA type. Human leukocyte-associated antigens testing of a potential donor is done before a donor stem cell or organ transplant, to find out if there is a tissue match between the donor and the person receiving the transplant.

**Host.** The person (patient) who receives the donated living cells in a transplant.

**Immune System.** Cells and proteins that defend the body against infection. Lymph nodes, lymphocytes the spleen, and white blood cells are some parts of the body’s immune system.

**Immunosuppressive Therapy.** Medication that reduces the patient’s working immune system in order to prevent rejection of the graft and also hinder development of graft-versus-host-disease.

**Jaundice.** A condition in which the skin and the whites of the eyes become yellow and the urine darkens. Jaundice occurs when the liver is not working properly.

**Leukocyte.** See White Blood Cell.

**Lymph Nodes.** Small structures, usually less than 1 centimeter that contain large numbers of lymphocytes and are connected with each other by small channels called “lymphatics.” These nodes are distributed throughout the body.

**Lymphocyte.** A type of white blood cell that is essential in the body’s immune system. There are three major types of lymphocytes: B lymphocytes, which produce antibodies to help combat infectious agents, such as bacteria, viruses and fungi; T lymphocytes, which have several functions, including assisting B lymphocytes to make antibodies; and natural killer (NK) cells, which can attack virus-infected cells or tumor cells.

**Marrow.** See Bone Marrow.

**Monocyte/Macrophage.** A type of white blood cell that constitutes about 5 to 10 percent of the cells in normal human blood. Monocytes and neutrophils are the two major microbe-eating and microbe-killing cells in the blood. When monocytes leave the blood and enter the tissue, they are converted to macrophages. The macrophage is the monocyte-in-action: It can combat infection in the tissues, ingest dead cells (in this function, it is called a “scavenger cell”) and assist lymphocytes in their immune functions.

**Neutropenia.** A decrease below normal in the number of blood neutrophils, a type of white blood cell.

**Neutrophil.** The principal phagocyte (microbe-eating cell) in the blood. This white blood cell is the main cell that combats infection. Often, it is not present in sufficient quantities in patients with acute leukemia or after chemotherapy, thus increasing their susceptibility to infection.

**Nonmyeloablative Stem Cell Transplantation.** See Reduced-Intensity Allogeneic Transplantation.

**Oncologist.** A doctor who diagnoses and treats patients who have cancer. An oncologist has special training to treat cancer in adults, and pediatric oncologists are specially trained to treat cancer in children. Radiation oncologists specialize in the use of radiation to treat cancer, and surgical oncologists specialize in the use of surgical procedures to diagnose and treat cancer. These doctors cooperate and collaborate to provide the best treatment plan (surgery, radiation therapy, chemotherapy or immunotherapy) for the patient.

**Opportunistic Infection.** Any unusual infection to which patients treated for cancer may be susceptible because of the suppression of their immune system. The word “opportunistic” is used to describe infections caused by bacteria, viruses, fungi or protozoa to which individuals with a normal immune system are not usually susceptible, but patients undergoing transplant have weakened immune systems and infections are more likely to occur.

**Pathologist.** A doctor who identifies disease by studying tissues under a microscope. A hematopathologist is a type of pathologist who studies diseases of blood cells by examining peripheral blood smears, bone marrow aspirates and biopsies, and lymph nodes and other tissues and uses his or her expertise to identify diseases. A hematopathologist uses the information gathered from examining tissue samples under the

microscope together with laboratory values, flow cytometry findings and molecular diagnostic test results to make the most accurate diagnosis. The hematopathologist works closely with the hematologist or oncologist who sees the patient and decides on the best treatment based upon the diagnosis.

**Peripheral Blood.** Blood that circulates throughout the body.

**Peripherally Inserted Central Venous Catheter (PICC or PIC Line).** A long, thin, flexible tube that is inserted into the body and can be left in place for weeks or even months for administration of medications, fluids and nutrition. It can also be used for drawing blood samples. Prior to insertion of the PICC, the patient is given a local anesthetic to numb the arm between the elbow and the shoulder. The PICC is inserted through the skin into a vein in the arm and advanced until it reaches the superior vena cava (one of the veins in the central venous system) that lies just above the heart. The PICC eliminates the need for standard intravenous (IV) administration.

**Phagocyte.** A cell that eats (ingests) microorganisms such as bacteria and fungi and kills them as a means of protecting the body against infection. The two principal phagocytes are neutrophils and monocytes. They leave the blood and enter tissues in which an infection has developed. A severe decrease in the concentrations of these cells is the principal cause of susceptibility to infection in patients treated with intensive radiation therapy and/or chemotherapy. Treatment may suppress blood cell production in the marrow, resulting in deficiencies of these protective cells.

**PICC or PIC line.** See Peripherally Inserted Central Venous Catheter.

**Platelets.** Small fragments of blood cells (a platelet is about one-tenth the size of a red cell) that stick to the site of blood vessel injury, aggregate and then seal off the injured blood vessel to stop bleeding. Thrombocyte (a synonym for “platelet”) is a term that identifies disorders of platelets such as thrombocytopenia (too few platelets) or thrombocythemia (too many platelets).

**Platelet Transfusion.** A transfusion of donor platelets may be needed to support some patients who have been treated for blood cancer. The platelets can be collected from several unrelated donors and given as pooled, random-donor unit. The platelets from about five single-unit blood donors are required to significantly raise the platelet count in a recipient. Sufficient platelets can be obtained from a single donor by a procedure known as “apheresis.” The platelets are skimmed from large volumes of blood passing through a specialized machine. The red blood cells and plasma are returned to the donor. The advantage of a transfusion that uses

single-donor platelets is that the patient is not exposed to the spectrum of antigens on platelets from many different people. The recipient of this type of transfusion is less likely to develop antibodies against donor platelets. A related donor who has either an identical or very similar HLA tissue type can donate matched platelets for transfusion.

**Port.** A small two-part central venous access device comprising an implantable self-sealing port attached to a catheter that is inserted into the subclavian vein. It is used with a central line to allow access to a vein. The port is implanted under the skin of the chest. After the insertion site heals, no dressings are needed. To administer medicines, parenteral nutrition or to draw blood samples for testing, the doctor or nurse inserts a needle through the skin into the port. A numbing cream can be put on the skin before the port is used. Ports must be flushed periodically. Patients and/or caregivers are given instructions about caring for the port. See Central Venous Catheter.

**Red Blood Cell.** A blood cell that carries the red-colored protein hemoglobin, which binds oxygen and delivers it to the tissues of the body. The red blood cells make up about 40 to 45 percent of the volume of the blood in healthy individuals. Another term for red blood cell is “erythrocyte.”

**Reduced-Intensity Allogeneic Stem Cell Transplantation.** A form of allogeneic transplantation in which patients receive lower doses of chemotherapy drugs and/or radiation in preparation for the transplant. Immunosuppressive drugs are used to prevent rejection of the graft (donor tissue). The engraftment of donor immune cells may allow these cells to attack the disease (graft-versus-tumor effect). Sometimes called “nonmyeloablative stem cell transplantation.”

**Refractory Disease.** Disease that is either resistant to or does not go into remission or improve substantially after initial therapy.

**Regional Anesthesia.** A temporary loss of feeling in a part of the body caused by special drugs called “anesthetics.” The patient remains awake but has no sensation in the part of the body treated with the anesthetic.

**Relapse/Recurrence.** The return or progression of disease that initially responded to therapy.

**Remission.** A disappearance of evidence of a disease, usually as a result of treatment. The words “complete” and “partial” are sometimes used to further describe remission. Complete remission means that all evidence of the disease is gone. Partial remission means that the disease is markedly

improved by treatment, but that some evidence of the disease remains. Long-term benefit usually requires a complete remission, especially in acute leukemia or progressive lymphoma.

**Spleen.** An organ located in the left upper portion of the abdomen just under the left side of the diaphragm. It contains clusters of lymphocytes and also filters old and worn-out cells from the blood. It is often affected in lymphocytic leukemia and lymphoma.

**Stem Cells.** Primitive cells in marrow that are essential to the formation of red blood cells, white blood cells and platelets. Stem cells are largely found in the bone marrow, but some leave the bone marrow and circulate in the blood. They are also found in the umbilical cord and placenta of newborn babies. Using special techniques, stem cells can be collected and used for stem cell therapy. See Hematopoiesis.

**Systemic.** Affecting the entire body.

**T cell.** A type of white blood cell. T cells are part of the immune system that help protect the body from infection and may also help fight cancer. Also called “T lymphocyte.”

**Thrombocytopenia.** A decrease below normal in the number of blood platelets (thrombocytes).

**T-Cell Depletion.** A process that decreases the number of T cells. Elimination of T cells from a bone marrow graft of a donor may reduce the chance of a patient incurring graft-versus-host disease.

**Veno-occlusive Disease (VOD).** A disease that may be a complication following high-dose chemotherapy and/or radiation, in which the blood vessels that carry blood through the liver swell and become clogged.

**Umbilical Cord Blood.** Blood from the umbilical cord of a newborn baby. This blood contains a high concentration of stem cells.

**White Blood Cell.** Any of the five major types of colorless, infection-fighting cells in the blood, which include neutrophils, eosinophils, basophils, monocytes and lymphocytes. Another term for white blood cell is “leukocyte.”

## Other Transplant Organizations

### **The American Society for Blood and Marrow Transplantation (ASBMT)**

**(847) 427-0224**

**[www.asbmt.org](http://www.asbmt.org)**

The American Society for Blood and Marrow Transplantation is an international professional association that promotes the advancement of blood and marrow transplantation both in clinical practice and in research.

### **Be The Match<sup>®</sup>, operated by the National Marrow Donor Program<sup>®</sup> (NMDP)**

**(888) 999-6743**

**[www.BeTheMatch.org](http://www.BeTheMatch.org)**

*Be The Match<sup>®</sup>* helps patients with leukemia, lymphoma and other diseases who need a marrow or umbilical cord blood transplant. People can join the Be The Match registry—the largest listing of potential marrow donors and donated cord blood units—contribute financially, and volunteer. Patients and their families can also turn to Be The Match for support and resources before, during and after transplant. Post-transplant care guidelines have been developed for patients. They can be accessed at [www.bethematch.org/patient](http://www.bethematch.org/patient).

### **Blood & Marrow Transplant Information Network (BMT InfoNet)**

**(888) 597-7674**

**[www.bmtinfonet.org](http://www.bmtinfonet.org)**

The Blood & Marrow Transplant Information Network (BMT InfoNet) is dedicated to providing transplant patients, survivors and their loved ones with emotional support and high quality, easy-to-understand information about bone marrow, peripheral blood stem cell and cord blood transplants.

### **The Center for International Blood & Marrow Transplant Research (CIBMTR)**

**(414) 805-0700**

**[www.cibmtr.org](http://www.cibmtr.org)**

The Center for International Blood and Marrow Transplant Research leads a worldwide collaboration of scientists and clinicians to advance understanding and outcomes of hematopoietic cell transplantation. This research helps assess donor safety and also helps identify the most promising transplant approaches and the patients most likely to benefit from a particular therapy.

### **National Bone Marrow Transplant Link (nbmtLINK)**

**(800) 546-5268**

**[www.nbmtlink.org](http://www.nbmtlink.org)**

The mission of the National Bone Marrow Transplant Link is to help patients, caregivers, and families cope with the social and emotional challenges of bone marrow/stem cell transplant from diagnosis through survivorship by providing vital information and personalized support services.

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- Discuss financial resources
- Receive individual clinical-trial searches



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For more information, please contact our Information Specialists **800.955.4572** (Language interpreters available upon request).

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