What are stem cells?

All of the blood cells in your body - white blood cells, red blood cells, and platelets - start out as young (immature) cells called **hematopoietic stem cells**. Hematopoietic means blood-forming. These are very young cells that are not fully developed. Even though they start out the same, these stem cells can mature into any type of blood cell, depending on what the body needs when each stem cell is developing.

Stem cells mostly live in the bone marrow (the spongy center of certain bones). This is where they divide to make new blood cells. Once blood cells mature, they leave the bone marrow and enter the bloodstream. A small number of the immature stem cells also get into the bloodstream. These are called **peripheral blood stem cells**.

Why stem cells are so important

Stem cells make red blood cells, white blood cells, andplatelets. We need all of these types of blood cells to keep us alive. For these blood cells to do their jobs, you need to have enough of each of them in your blood.

Red blood cells (RBCs)

Red blood cells carry oxygen away from the lungs to all of the cells in the body. They bring carbon dioxide from the cells back to the lungs to be exhaled. A blood test called a **hematocrit**shows how much of your blood is made up of RBCs. The normal range is about 35% to 50% for adults. People whose hematocrit is below this level have anemia[1]. This can make them look pale and feel weak, tired, and short of breath.

White blood cells (WBCs)

White blood cells help fight infections caused by bacteria, viruses, and fungi. There are different types of WBCs.

Neutrophils are the most important type in fighting infections. They are the first cells to respond to an injury or when germs enter the body. When they are low, you have a higher risk of infection[2]anemiaanemiaWBCs) ght infecti e are

lymphocytes, such as T lymphocytes (T cells), B lymphocytes (B cells), and natural killer (NK) cells. Some lymphocytes make antibodies to help fight infections. The body depends on lymphocytes to recognize its own cells and reject cells that don't belong in the body, such as invading germs or cells that are transplanted from someone else.

Platelets (thrombocytes)

Plateletsare pieces of cells that seal damaged blood vessels and help blood to clot, both of which are important in stopping bleeding. A normal platelet count is usually between 150,000/cubic mm and 450,000/cubic mm, depending on the lab that does the test. A person whose platelet count drops below normal is said to have **thrombocytopenia**, and may bruise more easily, bleed longer, and have nosebleeds or bleeding gums. Spontaneous bleeding (bleeding with no known injury) can happen if a person's platelet count drops lower than 20,000/mm^3. This can be dangerous if bleeding occurs in the brain, or if blood begins to leak into the intestines or stomach.

needle is put through the skin on the lower back and into the back of the hip bone. The thick liquid marrow is pulled out through the needle. This is repeated until enough marrow has been taken out. (For more on this, see What's It Like to Donate Stem Cells?)

The harvested marrow is filtered, stored in a special solution in bags, and then frozen. When the marrow is to be used, it's thawed and then put into the patient's blood through a vein, just like a blood transfusion. The stem cells travel to the bone marrow, where they engraft or "take" and start to make blood cells. Signs of the new blood cells usually can be measured in the patient's blood tests in a few weeks.

Peripheral blood

Normally, not many stem cells are found in the blood. But giving stem cell donors shots of hormone-like substances called **growth factors** a few days before the harvest makes their stem cells grow faster and move from the bone marrow into the blood.

For a peripheral blood stem cell transplant, the stem cells are taken from blood. A special thin flexible tube (called a catheter) is put into a large vein in the donor and attached to tubing that carries the blood to a special machine. The machine separates the stem cells from the rest of the blood, which is returned to the donor during the same procedure. This takes several hours, and may need to be repeated for a few days to get enough stem cells. The stem cells are filtered, stored in bags, and frozen until the patient is ready for them. (For more on this, see What's It Like to Donate Stem Cells?)

When they're given to the patient, the stem cells are put into a vein, much like a blood transfusion. The stem cells travel to the bone marrow, engraft, and then start making

Even though the blood of newborns has large numbers of stem cells, cord blood is only a small part of that number. So, a possible drawback of cord blood is the smaller number of stem cells in it. But this is partly balanced by the fact that each cord blood stem cell can form more blood cells than a stem cell from adult bone marrow. Still, cord blood transplants can take longer to take hold and start working. Cord blood is given into the patient's blood just like a blood transfusion.

Cancers that affect the bone marrow

Some cancers start in the bone marrow and others can spread to it. Cancer attacks the bone marrow, causing it to make too many of some cells that crowd out others, or causing it to make cells that aren't healthy and don't work like they should. For these cancers to stop growing, they need bone marrow cells to work properly and start making new, healthy cells.

Most of the cancers that affect bone marrow function are leukemias[4], multiple multipbrg /GS165 gs (bo8multipbrg /GS165 gem cell can form me)ns (,)Te9irrow12 Tf 0 0 0 rg /GS171

cells from another person (not the cancer patient). In these cases, the transplant can help treat certain types of cancer in a way other than just replacing stem cells. Donated cells can often find and kill cancer cells better than the immune cells of the person who had the cancer ever could. This is called the “graft-versus-cancer” or “graft-versus-leukemia” effect. The "graft" is the donated cells. The effect means that certain kinds of transplants actually help kill off the cancer cells, along with rescuing bone marrow and allowing normal blood cells to develop from the stem cells.

Deciding to have a stem cell transplant

Although a stem cell transplant can help some patients, even giving some people a chance for a cure, the decision to have a transplant isn’t easy. Like everything in your medical care, you need to be the one who makes the final choice about whether or not you’ll have a stem cell transplant. Transplant has been used to cure thousands of people with otherwise deadly cancers. Still, there are possible risks and complications that can threaten life, too. People have died from complications of stem cell transplant. The expected risks and benefits must be weighed carefully before transplant.

Your cancer care team will compare the risks linked with the cancer itself to the risks of the transplant. They may also talk to you about other treatment options or clinical trials[9]. The stage of the cancer, patient’s age, time from diagnosis to transplant, donor type, and the patient’s overall health are all part of weighing the pros and cons before making this decision.

- What type of treatment will I need before the transplant?
- How much will a transplant cost?
- What costs, if any, will my insurance cover? How much will I have to pay?
- Will it cover the costs of finding a donor?
- Will I be able to have children after the transplant? What are my options if I want to have children later?
- What side effects might I expect? How bad will they be? How long will they last?
- What types of medicine or self-care will be used to control side effects?
- How long might I have to be in the hospital?
- Will I be able to have visitors?
- What type of follow-up will be needed? How often?
- What vaccines will I need to get after transplant and when will I get them?
- What are the chances that the cancer will come back[11] after transplant?
- When will I be able to return to work?

Be sure to express all your concerns and get answers you understand. Make sure the team knows what's important to you, too. Transplant is a complicated process. Find out as much as you can and plan ahead before you start.

It's important to know the success rate of the planned transplant based on your diagnosis[12]and stage in treatment, along with any other conditions that might affect you and your transplant. In general, transplants tend to work better if they're done in early stages of disease or when you're in remission, when your overall health is good. Ask about these factors and how they affect the expected outcomes of your transplant or other treatment.

Many people get a second opinion[13] before they decide to have a stem cell transplant. You may want to talk to your doctor about this, too. Also, call your health insurance company to ask if they will pay for a second opinion before you go. You might also want to talk with them about your possible transplant, and ask which transplant centers are covered by your insurance.

Cost of transplant

Stem cell transplants cost a lot, and some types cost more than others. For example, getting a donor's cells costs more than collecting your own cells. And, different drug and radiation treatments used to destroy bone marrow can have high costs. Some transplants require more time in the hospital than others, and this can affect cost. Even though there are differences, stem cell transplants can cost hundreds of thousands of

dollars.

A transplant (or certain types of transplants) is still considered experimental for some types of cancer, especially some solid tumor cancers, so insurers might not cover the cost.

No matter what illness you have, it's important to find out what your insurer will cover before deciding on a transplant, including donor match testing, cell collection, drug treatments, hospital stay, and follow-up care. Go over your transplant plan with them to find out what's covered. Ask if the doctors and transplant team you plan to use are in their network, and how reimbursement will work. Some larger insurance companies have transplant case managers. If not, you might ask to speak with a patient advocate. You can also talk with financial or insurance specialists at your doctor's office, transplant center, and hospital about what expenses you are likely to have. This will help you get an idea of what you might have to pay in co-pays and/or co-insurance.

Hyperlinks

1. www.cancer.org/cancer/managing-cancer/side-effects/low-blood-counts/anemia.html
2. www.cancer.org/cancer/managing-cancer/side-effects/infections.html
3. www.cancer.org/cancer/diagnosis-staging/tests/understanding-your-lab-test-results.html
4. www.cancer.org/cancer/types/leukemia.html
5. www.cancer.org/cancer/types/multiple-myeloma.html
6. www.cancer.org/cancer/types/lymphoma.html
7. www.cancer.org/cancer/managing-cancer/treatment-types/chemotherapy.html
8. www.cancer.org/cancer/managing-cancer/treatment-types/radiation.html

American Society of Clinical Oncology (ASCO). What is a stem cell transplant (bone marrow transplant)? Accessed at cancer.net. Content is no longer available.

Im A, Pavletic SZ. Hematopoietic stem cell transplantation. In Niederhuber JE, Armitage

Types of Stem Cell and Bone Marrow Transplants

chemo[1], sometimes along with radiation therapy[2], to try to kill all the cancer cells. This treatment also kills the stem cells in the bone marrow. This is called **myeloablation** or **myeloablative therapy**.

Soon after treatment, blood stem cells are given (transplanted) to replace those that were destroyed. The replacement stem cells are given into a vein, much like a blood transfusion. The goal is that over time, the transplanted cells will settle in the bone marrow, where they will begin to grow and make healthy new blood cells. This process is called **engraftment**.

There are 2 main types of transplants. They are named based on who donates the stem cells.

- **Autologous:** 'Auto' means **self**. The stem cells in autologous transplants come from the same person who will get the transplant, so the patient is their own donor.
- **Allogeneic:** 'Allo' means **other**. The stem cells in allogeneic transplants are from a person other than the patient, either a matched related or unrelated donor.

Autologous stem cell transplants

In this type of transplant, the first step is to remove or **harvest** your own stem cells. Your stem cells are removed from either your bone marrow or your blood, and then frozen. (You can learn more about this process at What's It Like to Donate Stem Cells?) After you get high doses of chemo and/or radiation as your myeloablative therapy, the stem cells are thawed and given back to you.

This kind of transplant is mainly used to treat certain leukemias, lymphomas, and multiple myeloma. It's sometimes used for other cancers, like testicular cancer and neuroblastoma, and certain cancers in children. Doctors can use autologous transplants for other diseases, too, like systemic sclerosis, multiple sclerosis (MS), Crohn's disease, and systemic lupus erythematosus (lupus).

Benefits of autologous stem cell transplant

An advantage of an autologous stem cell transplant is that you're getting your own cells back. When you getyour own stem cells back, you don't have to worry about them (called the engrafted cells or the "graft") being rejected by your body. You also don't have to worry about immune cells from the transplant attacking healthy cells in your body (known as **graft-versus-host disease**), which is a concern with allogeneic transplants.

Risks of autologous stem cell transplant

An autologous transplant graft might still fail, which means the transplanted stem cells don’t go into the bone marrow and make blood cells like they should.

Also, autologous transplants can’t produce the “graft-versus-cancer” effect, in which the donor immune cells from the transplant help kill any cancer cells that remain.

Another possible disadvantage of an autologous transplant is that cancer cells might be collected along with the stem cells and then later be put back into your body.

Getting rid of cancer cells in stem cells saved for autologous transplants

To help prevent any remaining cancer cells from being transplanted along with stem cells, some centers treat the stem cells before they’re given back to the patient. This may be called **purging**. While this might work for some patients, there haven't been enough studies yet to know if this is really a benefit. A possible downside of g /F2 1to know if this iss42

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types of the childhood cancer neuroblastoma and adult multiple myeloma are cancers where tandem transplants seem to show good results. But doctors don't always agree that these are really better than a single transplant for certain cancers. Because this treatment involves 2 transplants, the risk of serious outcomes is higher than for a single transplant.

Sometimes an autologous transplant followed by an allogeneic transplant might also be called a tandem transplant. (See Mini-transplants below.)

Allogeneic stem cell transplants (including cord blood transplants)

Allogeneic stem cell transplants use donor stem cells. In the most common type of allogeneic transplant, the stem cells come from a donor whose tissue type closely matches yours. (This is discussed in "Matching patients and donors.") The best donor is a close family member, usually a brother or sister. If you don't have a good match in your family, a donor might be found in the general public through a national registry. This is sometimes called a **MUD (matched unrelated donor) transplant**. Transplants with a MUD are usually riskier than those with a relative who is a good match.

An allogeneic transplant works about the same way as an autologous transplant. Stem cells are collected from the donor and stored or frozen. After you get high doses of chemo and/or radiation as your myeloablative therapy, the donor's stem cells are thawed and given to you.

Allogeneic transplants are most often used to treat certain types of leukemia, lymphomas, multiple myeloma, myelodysplastic syndromes, and other bone marrow disorders such as aplastic anemia.

Umbilical cord blood transplant

Blood taken from the placenta and umbilical cord after a baby is born can also be used for an allogeneic transplant. This small volume of **cord blood** has a high number of stem cells in it.

Cord blood transplants can have some advantages. For example, there are already a large number of donated units in cord blood banks, so finding a donor match might be easier. These units have already been donated, so they don't need to be collected once a match is found. A cord blood transplant is also less likely to be rejected by your body than is a transplant from an adult donor.

But cord blood transplants can have some downsides as well. There aren't as many

stem cells in a cord blood unit as there are in a typical transplant from an adult donor. Because of this, cord blood transplants are used more often for children, who have smaller body sizes. These transplants can be used for adults as well, although sometimes a person might need to get more than one cord blood unit to help ensure there are enough stem cells for the transplant.

Cord blood transplants can also take longer to begin making new blood cells, during which time a person is vulnerable to infections and other problems caused by having low blood cell counts. For a newer cord blood product, known as omidubicel (Omisirge), the cord blood cells are treated in a lab with a special chemical, which helps them get to the bone marrow and start making new blood cells quicker once they're in the body.

Benefits of allogeneic stem cell transplant

A major benefit of allogeneic transplants is that the donor stem cells make their own immune cells, which could help kill any cancer cells that remain after high-dose treatment. This is called the **graft-versus-cancer** or **graft-versus-tumor**effect.

Other advantages are that the donor can often be asked to donate more stem cells or even white blood cells if needed (although this isn't true for a cord blood transplant), and stem cells from healthy donors are free of cancer cells.

Risks of allogeneic stem cell transplants

As with any type of transplant, there is a risk that the transplant, or graft, might not take – that is, the transplanted donor stem cells could die or be destroyed by the patient's body before settling in the bone marrow.

Another risk is that the immune cells from the donor could attack healthy cells in the patient's body. This is called graft-versus-host disease, and it can range from mild to life-threatening.

There is also a very small risk of certain infections from the donor cells, even though donors are tested before they donate.

Another risk is that some types of infections you had previously and which your immune system has had under control may resurface after an allogeneic transplant. This can happen when your immune system is weakened (suppressed) by medicines called **immunosuppressive**drugs. Such infections can cause serious problems and can even be life-threatening.

chance of graft-versus-host disease, graft rejection, having a weak immune system, and getting serious infections. For bone marrow and peripheral blood stem cell transplants, sometimes a donor with a single mismatched antigen is used – a 5 out of 6 match. For cord blood transplants a perfect HLA match doesn't seem to be as important, and even a sample with a couple of mismatched antigens may be OK.

Doctors keep learning more about better ways to match donors. Today, fewer tests may be needed for siblings, since their cells vary less than an unrelated donor. But to reduce the risks of mismatched types between unrelated donors, more than the basic 6 HLA antigens may be tested. For example, sometimes doctors to try and get a 10 out of 10 match. Certain transplant centers now require high-resolution matching, which looks more deeply into tissue types and allow more specific HLA matching.

Finding a match

There are thousands of different combinations of possible HLA tissue types. This can make it hard to find an exact match. HLA antigens are inherited from both parents. If possible, the search for a donor usually starts with the patient's brothers and sisters (siblings), who have the same parents as the patient. The chance that any one sibling would be a perfect match (that is, that you both received the same set of HLA antigens from each of your parents) is 1 out of 4.

If a sibling is not a good match, the search could then move on to relatives who are less likely to be a good match – parents, half siblings, and extended family, such as aunts, uncles, or cousins. (Spouses are no more likely to be good matches than other people who are not related.) If no relatives are found to be a close match, the transplant team will widen the search to the general public.

As unlikely as it seems, it's possible to find a good match with a stranger. To help with this process, the team will use transplant registries, like those listed here. Registries serve as matchmakers between patients and volunteer donors. They can search for and access millions of possible donors and hundreds of thousands of cord blood units.

Be the Match (formerly the **National Marrow Donor Program)** Toll-free number: 1-800-MARROW-2 (1-800-627-7692) Website: www.bethematch.org[4]

Blood & Marrow Transplant Information Network Toll-free number: 1-888-597-7674 Website: www.bmtinfonet.org[5]

chance of finding a perfect match for stem cell transplant among unrelated donors. This is because ethnic groups have differing HLA types, and in the past there was less diversity in donor registries, or fewer non-White donors. However, the chances of finding an unrelated donor match improve each year, as more volunteers become aware of registries and sign up for them.

Finding an unrelated donor can take months, though cord blood may be a little faster. A single match can require going through millions of records. Also, now that transplant centers are more often using high-resolution tests, matching is becoming more complex. Perfect 10 out of 10 matches at that level are much harder to find. But transplant teams are also getting better at figuring out what kinds of mismatches can be tolerated in which particular situations – that is, which mismatched antigens are less likely to affect transplant success and survival.

Keep in mind that there are stages to this process – there may be several matches that look promising but don't work out as hoped. The team and registry will keep looking for the best possible match for you. If your team finds an adult donor through a transplant registry, the registry will contact the donor to set up the final testing and donation. If your team finds matching cord blood, the registry will have the cord blood sent to your transplant center.

Hyperlinks

1. www.cancer.org/cancer/managing-cancer/treatment-types/chemotherapy.html
2. www.cancer.org/cancer/managing-cancer/treatment-types/radiation.html
3. www.cancer.org/cancer/managing-cancer/side-effects/infections.html
4. www.bethematch.org/
5. www.bmtinfonet.org/

References

American Society of Clinical Oncology (ASCO). Bone marrow aspiration and

marrow transplant)? Accessed at cancer.net. Content is no longer available.

Atilla E, Atilla PA, Demirer T. A review of myeloablative vs reduced intensity/non-myeloablative regimens in allogeneic hematopoietic stem cell transplantations. *Balkan Med J.* 2017;34(1):1-9. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5322516/ on March 17, 2020.

Ballen K. Umbilical cord blood transplantation: Challenges and future directions. *Stem Cells Transl Med*. 2017; 6(5):1312-1315. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5442719/ on Aug 1, 2019.

Im A, Pavletic SZ. Hematopoietic stem cell transplantation. In Niederhuber JE, Armitage JO, Kastan MB, Doroshow JH, Tepper JE, eds. *Abeloff's Clinical Oncology.* 6th ed. Philadelphia, PA: Elsevier;2020:461-469.

Nathan S, Ustun C. Complications of stem cell transplantation that affect infections in stem cell transplant recipients, with analogies to patients with hematologic malignancies. *Infect Dis Clin North Am*. 2019; 33(2):331-359.

National Institutes of Health (NIH). Stem cell basics. 2016. Access at https://stemcells.nih.gov/info/basics.htm on March 17, 2020.

National Cancer Institute (NCI). Adult acute lymphoblastic leukemia treatment (PDQ®): Health professional version. 2019. Accessed at https://www.cancer.gov/types/leukemia/hp/adult-all-treatment-pdq on March 17, 2020.

National Cancer Institute (NCI). Childhood hematopoietic cell transplantation (PDQ®): Health professional version. 2019. Accessed at https://www.cancer.gov/types/childhood-cancers/child-hct-hp-pdq on March 17, 2020.

National Comprehensive Cancer Network (NCCN). Multiple myeloma: NCCN Clinical Practice Guidelines in Oncology. Version 3.2020. Accessed at https://www.nccn.org/patients/guidelines/myeloma/ on March 17, 2020.

Saygin C, Matei D, Majeti R, et al. Targeting cancer stemness in the clinic: From hype to hope. *Cell Stem Cell*. 2019; 24(1):25-40.

Soiffer RJ, Chen YB. Pharmacologic agents to prevent and treat relapse after allogeneic hematopoietic cell transplantation. *Hematology Am Soc Hematol Educ Program*. 2017; 1:699-707. Access at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6142540/ on March 17, 2020.

Zhang L, Yu J, Wei W. Advances in targeted immunotherapy for graft-versus-host disease. *Front Immunol*. 2018;9:1087. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5964137/ on March 17, 2020.

Zhao XS, Huang XJ. Seeking biomarkers for acute graft-versus host disease: Where we are and where we are heading? *Biomark Res.* 2019; 7:17. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6685226/ on March 17, 2020.

Last Revised: May 4, 2023

Donating Stem Cells and Bone Marrow

People usually volunteer to donate stem cells for an allogeneic transplant either because they have a loved one or friend who needs a match or because they want to help people. Some people give their stem cells so they can get them back later if they need an autologous transplant.

If you want to donate stem cells for someone else

Medical guidelines are in place to protect the health of potential donors, as well as the health of bone marrow and stem cell transplant patients. Many factors can affect if a person is eligible to register as a donor.

People, including cancer survivors, who want to donate stem cells or join a volunteer registry can check the eligibility list available through the registry. They can also speak with a health care provider or contact the National Marrow Donor Program to find the nearest donor center. Potential donors are asked questions to make sure they are healthy enough to donate and don't pose a risk of infection to the recipient. For more information about donor eligibility guidelines, contact Be the Match or the donor center in your area.

Be the Match (formerly the **National Marrow Donor Program)** Toll-free number: 1-800-MARROW-2 (1-800-627-7692) Website: www.bethematch.org[1]

A simple blood test is done to learn the potential donor's HLA type. There may be a one-time, tax-deductible fee of about $75 to $100 for this test. People who join a volunteer donor registry will most likely have their tissue type kept on file until they reach age 60.

Pregnant women who want to donate their baby's cord blood should make arrangements for it early in the pregnancy, at least before the third trimester. Donation is safe, free, and does not affect the birth process.

Before the donation: Informed consent and further testing

If a possible stem cell donor is found to be a good match for a recipient, steps are taken to teach the donor about the transplant process and make sure they are making an informed decision. If a person decides to donate, a consent form must be signed after the risks of donating are fully discussed. The donor is not pressured to take part. It's always a choice.

If a person decides to donate, a medical exam and blood tests will be done to make sure they are in good health.

How stem cells are collected

Stem cells may be collected from these 3 different sources:

- Bone marrow
- Peripheral stem cells
- Umbilical cord blood

Each method of collection is explained here.

Collecting bone marrow stem cells

This process is often called **bone marrow harvest**. It's done in an operating room, while the donor is under general anesthesia (given medicine to put them into a deep sleep so they don't feel pain). The marrow cells are taken from the back of the pelvic (hip) bone. The donor lies face down, and a large needle is put through the skin and into the back of the hip bone. It's pushed through the bone to the center and the thick, liquid marrow is pulled out through the needle. This is repeated several times until enough marrow has been taken out (harvested). The amount taken depends on the donor's weight. Often, about 10% of the donor's marrow, or about 2 pints, are collected. This

takes about 1 to 2 hours. The body will replace these cells within 4 to 6 weeks. If blood was taken from the donor before the marrow donation, it's often given back to the donor at this time.

After the bone marrow is harvested, the donor is taken to the recovery room while the anesthesia wears off. The donor may then be taken to a hospital room and watched until fully alert and able to eat and drink. In most cases, the donor is able to leave the hospital within a few hours or by the next morning.

The donor may have soreness, bruising, and aching at the back of the hips and lower back for a few days. Over-the-counter pain medications or nonsteroidal anti-inflammatory drugs are helpful. Some people may feel tired or weak, and have trouble walking for a few days. The donor might be told to take iron supplements until the number of red blood cells returns to normal. Most donors get back to their usual activities in 2 to 3 days. But it could take 2 or 3 weeks before they feel completely back to normal.

There aren't many risks for donors and serious complications are rare. But bone marrow donation is a surgical procedure. Rare complications could include anesthesia reactions, infection, nerve or muscle damage, transfusion reactions (if a blood transfusion of someone else's blood is needed – this doesn't happen if you get your own blood), or injury at the needle insertion sites. Problems such as sore throat or nausea may be caused by anesthesia.

Allogeneic stem cell donors do not have to pay for the harvesting because the recipient's insurance company usually covers the cost. Even so, be sure to ask about insurance coverage before you decide to have the bone marrow harvest done.

Once the cells are collected, they are filtered through fine mesh screens. This prevents bone or fat particles from being given to the recipient. For an allogeneic or syngeneic transplant, the cells may be given to the recipient through a vein soon after they are harvested. Sometimes they're frozen, for example, if the donor lives far away from the recipient.

Collecting peripheral blood stem cells

For several days before starting the donation process, the donor is given a daily injection (shot) of a drug that causes the bone marrow to make and release a lot of stem cells into the blood. Filgrastim can cause some side effects, the most common being bone pain and headaches. These may be helped by over-the-counter pain medications or nonsteroidal anti-inflammatory drugs. Nausea[2], sleeping problems[3], low-grade (mild) fevers, and tiredness are other possible effects. These go away once the injections are

finished and collection is completed.

After the shots, blood is removed through a catheter (a thin, flexible plastic tube) that's put in a large vein in the arm. It's then cycled through a machine that separates the stem cells from the other blood cells. The stem cells are kept while the rest of the blood is returned to the donor, often through the same catheter. (In sor. (s9sthe goh 0 0moTst of t mhs (is rt

newborn’s cord blood, call 1-800-MARROW2 (1-800-627-7692) or visit Be the Match[6].

Other parents store their newborn’s cord blood in private cord blood banks just in case the child or a close relative needs it someday. If you want to donate or bank (save) your child’s cord blood, you’ll need to arrange it before the baby is born. Some banks require

4. www.cancer.org/cancer/managing-cancer/side-effects/infections/managing-infections-and-sepsis.html
5. www.cancer.org/cancer/managing-cancer/side-effects/low-blood-counts/blood-clots.html
6. bethematch.org/support-the-cause/donate-cord-blood/
7. www.parentsguidecordblood.org/

References

American Society of Clinical Oncology (ASCO). Bone marrow aspiration and biopsy. Accessed at cancer.net. Content is no longer available.

American Society of Clinical Oncology (ASCO). What is a stem cell transplant (bone marrow transplant)? Accessed at cancer.net. Content is no longer available.

Im A, Pavletic SZ. Hematopoietic stem cell transplantation. In Niederhuber JE, Armitage JO, Kastan MB, Doroshow JH, Tepper JE, eds. *Abeloff's Clinical Oncology.* 6th ed. Philadelphia, PA: Elsevier;2020:461-469.

National Institutes of Health (NIH). Stem cell basics. 2016. Access at https://stemcells.nih.gov/info/basics.htm on March 17, 2020.

Last Revised: August 4, 2020

Getting a Stem Cell or Bone Marrow Transplant

When the decision is made to have a stem cell or bone marrow transplant, there are several steps in the process. The steps are much the same, no matter what type of transplant you're going to have.

- Evaluation and preparation for a transplant
- Hospital admission or outpatient treatment for transplants
- Conditioning treatment (chemo and/or radiation therapy)
- Infusion of stem cells
- Recovery after infusion
- Discharge from the hospital after transplant
- Rehabilitation after stem cell transplant

Evaluation and preparation for a transplant

You will first be evaluated to find out if you are eligible for a transplant. A transplant is very hard on your body. For many people, transplants can mean a cure, but for some people, problems can lead to severe complications or even death. You'll want to weigh the benefits and risks before you start.

Transplants can also be hard emotionally. They often require being in the hospital, being isolated, and there's a high risk of side effects. Many of the effects are short-term, but some problems can go on for years. This can mean changes in the way you live your life. For some people it's just for a while, but for others, the changes may be lifelong. Some of the side effects are really unpleasant and can be serious. Your cancer care team will do everything they can to make you comfortable, but some of the side effects may not be completely controlled or relieved.

Before you have a transplant, you need to discuss the transplant process and all its effects with your doctors. It also helps to talk with others who have already had transplants.

It's also very hard going through weeks and months of not knowing how your transplant will turn out. This takes a lot of time and emotional energy from the patient, caregivers, and loved ones. It's very important to have the support of those close to you. For example, you'll need a responsible adult who will be with you to give you medicines, help watch for problems, and stay in touch with your transplant team after you go home. Your transplant team will help you and your caregiver learn what you need to know. The team can also help you and your loved ones work through the ups and downs as you prepare for and go through the transplant.

Many different medical tests will be done, and questions will be asked to try to find out how well you can handle the transplant process. These might include:

- HLA tissue typing (this is a blood test)

- A complete health history and physical exam
- Evaluation of your psychological and emotional strengths
- Identifying who will be your primary caregiver throughout the transplant process
- Bone marrow biopsy (this is a medical procedure that happens in the hospital or clinic)
- CT (computed tomography) scan or MRI (magnetic resonance imaging)
- Heart tests, such as an EKG (electrocardiogram) or echocardiogram
- Lung studies, such as a chest x-ray and PFTs (pulmonary function tests)
- Appointments with other members of the transplant team, such as a dentist, dietitian, or social worker
- Blood tests, such as a complete blood count, blood chemistries, and screening for viruses like hepatitis B, CMV, and HIV

You will also talk about your health insurance coverage and related costs that you might have to pay.

You may have a central venous catheter (CVC)[1] put into a large vein in your chest. This is most often done as outpatient surgery, and usually only local anesthesia is needed (the place where the catheter goes in is made numb). Nurses will use the catheter to draw blood and give you medicines.

If you're getting an autologous transplant, a special catheter can be placed that can also be used when your stem cells are being removed or harvested.

The CVC will stay in during your treatment and for some time afterward, usually until your transplanted stem cells have engrafted and your blood counts are on a steady climb to normal.

Transplant eligibility

Younger people, people who are in the early stages of disease, or those who have not already had a lot of treatment, often do better with transplants. Some transplant centers set age limits. Some people also may not be eligible for transplant if they have other major health problems, such as serious heart, lung, liver, or kidney disease. A mini-transplant, described under Allogeneic stem cell transplant in Types of Stem Cell Transplants for Cancer Treatment may be an option for some of these people.

Hospital admission or outpatient treatment for transplants

The hospital's transplant team will decide if you need to be in the hospital to have your transplant, if it will be done in an outpatient center, or if you will be in the hospital just for parts of it. If you have to be in the hospital, you will probably go in the day before pre-transplant chemo or radiation treatment begins (see the next section), the transplant team makes sure you and your family understand the process and want to go forward with it.

If you will be having all or part of your transplant as an outpatient, you'll need to be very near the transplant center during the early stages. You'll need a family member or loved one to be a caregiver who can stay with you all the time. You and the caregiver will also need reliable transportation to and from the clinic. The transplant team will be watching you closely for complications, so expect to be at the clinic every day for a few weeks. You may still need to be in the hospital if your situation changes or if you start having complications.

To reduce the chance of infection

- To make room in the bone marrow for the transplanted stem cells
- To suppress the patient's immune system to lessen the chance of graft rejection
- To destroy any remaining cancer cells in the patient's body

The conditioning treatment is different for every transplant. Your treatment will be planned based on the type of cancer you have, the type of transplant, and any chemo or radiation therapy you've had in the past.

If chemo is part of your treatment plan, it will be given in your central venous catheter and/or as pills. If radiation therapy is planned, it's given to the entire body (called **total body irradiation** or **TBI**). TBI may be given in a single treatment session or in divided doses over a few days.

This phase of the transplant can be very uncomfortable because very high treatment

Infusion side effects

Side effects from the infusion[10] are rare and usually mild. The preserving agent used when freezing the stem cells causes many of the side effects. For instance, you might have a strong taste of garlic or creamed corn in your mouth. Sucking on candy or sipping flavored drinks during and after the infusion can help with the taste. Your body will also smell like this. The smell may bother those around you, but you might not even notice it. The smell, along with the taste, may last for a few days, but slowly fades away. Often having cut up oranges in the room will offset the odor. Patients who have transplants from cells that were not frozen do not have this problem because the cells are not mixed with the preserving agent.

Other side effects[11] you might have during and right after the stem cell infusion include:

- Fever or chills
- Shortness of breath
- Hives
- Tightness in the chest
- Low blood pressure
- Coughing
- Chest pain
- Less urine output
- Feeling weak

Again, side effects are rare and usually mild. If they do happen, they are treated as needed. The stem cell infusion must always be completed.

Recovery after infusion

The recovery stage begins after the stem cell infusion. During this time, you and your family wait for the cells to engraft, or “take,” after which they start to multiply and make new blood cells. The time it takes to start seeing a steady return to normal blood counts varies depending on the patient and the transplant type, but it’s usually about 2 to 6 weeks. You’ll be in the hospital or visit the transplant center daily for a number of weeks.

During the first couple of weeks you’ll have low numbers of red and white blood cells and platelets. Right after transplant, when your counts are the lowest, you may be given antibiotics to help keep you from getting infections. You may get a combination of anti-bacterial, anti-fungal, and anti-viral drugs. These are usually given until your white blood

cell count reaches a certain level. Still, you can have problems, such as infection from too few white blood cells (neutropenia)[12], or bleeding from too few platelets (thrombocytopenia[13]). Many patients have high fevers and need IV antibiotics to treat serious infections. Transfusions[14] of red blood cells and platelets are often needed until the bone marrow starts working and new blood cells are being made by the infused stem cells.

Except for graft-versus-host disease, which only happens with allogeneic transplants, the side effects from autologous, allogeneic, and syngeneic stem cell transplants are much the same. Problems may include stomach, heart, lung, liver, or kidney problems. (Stem Cell Transplant Side Effects goes into the details.) You might also go through feelings of distress, anxiety, depression, joy, or anger. Adjusting emotionally after the stem cells can be hard because of the length of time you feel ill and isolated from others.

You might feel as if you are on an emotional roller coaster during this time. Support and encouragement from family, friends, and the transplant team are very important to get you through the challenges after transplant.

Discharge from the hospital after transplant

The discharge process actually begins weeks before your transplant. It starts with the transplant team teaching you and your primary (main) caregiver about:

- The precautions you'll need to take
- Who will be your primary caregiver and what the job will be like, and who will be the back-up caregiver in case your main caregiver gets sick and can't be near you
- How to prepare your home
- How to care for your central venous catheter
- How to take good care of your mouth and teeth
- What foods you should and shouldn't eat
- Activities you can and can't do
- When to call the transplant team or other health care providers

What has to happen before you can go home?

For the most part, transplant centers don't send patients home until they meet the following criteria:

- No fever for 48 hours
- Able to take and keep down pills or other drugs for 48 hours
- Nausea, vomiting, and diarrhea are controlled with medicine

- Low thyroid function
- Overwhelming tiredness (fatigue)
- Limited ability to exercise
- Slowed growth and development (in children)
- Cataracts
- Reproductive or sexual problems, like infertility, early menopause, pain or discomfort during sex, or loss of interest in sex
- New cancers caused by the transplant

Other problems can also come up, such as:

- Memory loss, trouble concentrating
- Emotional distress, depression, body image changes, anxiety
- Social isolation
- Changes in relationships
- Changes in how you view the meaning of life
- Feeling indebted to others
- Job and insurance concerns

Your transplant team is still there to help you, even though the transplant happened months ago. It's important that you tell them about any problems you are having – they can help you get the support you need to manage the changes that you are going through. They can also help you know if problems are serious, or a normal part of recovery. The National Bone Marrow Transplant Link helps patients, caregivers, and families by providing information and support services before, during, and after transplant. They can be reached at 1-800-LINK-BMT (1-800-546-5268) or online at www.nbmtlink.org[16].

Hyperlinks

1. www.cancer.org/cancer/managing-cancer/making-treatment-decisions/tubes-lines-ports-catheters.html
2. www.cancer.org/cancer/managing-cancer/side-effects/infections.html
3. www.cancer.org/cancer/managing-cancer/treatment-types/chemotherapy.html
4. www.cancer.org/cancer/managing-cancer/treatment-types/radiation.html
5. www.cancer.org/cancer/managing-cancer/side-effects/eating-problems/mouth-

sores.html
6. www.cancer.org/cancer/managing-cancer/side-effects/eating-problems/nausea-and-vomiting.html
7. www.cancer.org/cancer/managing-cancer/side-effects/hair-skin-nails/hair-loss.html
8. www.cancer.org/cancer/managing-cancer/side-effects/shortness-of-breath.html
9. www.cancer.org/cancer/managing-cancer/side-effects/fertility-and-sexual-side-effects.html
10. www.cancer.org/cancer/managing-cancer/side-effects/infusion-immune-reactions.html
11. www.cancer.org/cancer/managing-cancer/side-effects.html
12. www.cancer.org/cancer/managing-cancer/side-effects/low-blood-counts/neutropenia.html
13. www.cancer.org/cancer/managing-cancer/side-effects/low-blood-counts/bleeding.html
14. www.cancer.org/cancer/managing-cancer/treatment-types/blood-transfusion-and-donation.html
15. www.cancer.org/cancer/diagnosis-staging/tests/understanding-your-lab-test-results.html
16. www.nbmtlink.org/

References

American Society of Clinical Oncology (ASCO). Bone marrow aspiration and biopsy. Accessed at cancer.net. Content is no longer available.

American Society of Clinical Oncology (ASCO). Side effects of a bone marrow transplant (stem cell transplant). Accessed at cancer.net. Content is no longer available.

American Society of Clinical Oncology (ASCO). What is a stem cell transplant (bone marrow transplant)? Accessed at cancer.net. Content is no longer available.

Atilla E, Atilla PA, Demirer T. A review of myeloablative vs reduced intensity/non-myeloablative regimens in allogeneic hematopoietic stem cell transplantations. *Balkan Med J.* 2017;34(1):1-9. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5322516/ on March 17, 2020.

Im A, Pavletic SZ. Hematopoietic stem cell transplantation. In Niederhuber JE, Armitage

Stem Cell or Bone Marrow Transplant Side Effects

Your transplant team can help you cope with side effects. Some can be prevented, and most can be treated to help you feel better. This is not a complete list and you should tell your doctor or transplant team about any problems you have or changes you notice. Some of these problems can be life-threatening, so it's important to be able to reach your doctor or transplant team at night, on weekends, and during holidays. Ask for their after hours contact numbers to make sure you will be able to do this.

Mouth and throat pain

Mucositis (inflammation or sores in the mouth[1]) is a short-term side effect that can happen with chemo and radiation. It usually gets better within a few weeks after treatment, but it can make it very painful to eat and drink.

Good nutrition is important for people with cancer. If mouth pain or sores make it hard to eat or swallow, your transplant team can help you develop a plan to manage your symptoms.

Nausea and vomiting

Because chemotherapy drugs can cause severe nausea and vomiting[2], doctors often

You may be given antibiotics to try to prevent infections until your blood counts reach a certain level. For instance, pneumocystis pneumonia (often called PCP) is a common infection that's easy to catch. Even though the germ doesn't harm people with normal immune systems, for others it can cause fever, cough, and serious breathing problems. Antibiotics are often used to keep transplant patients from getting this.

Your doctor may check you before the transplant for signs of certain infections that may become active after transplant, and give you special medicines to keep those germs under control. For example, the virus called **CMV** (cytomegalovirus) is a common infection that many adults have or had in the past. Adults with healthy immune systems may not have any symptoms because their immune system can keep the virus under control. But, CMV can be a cause of serious pneumonia in people who have had transplants, because the transplant lowers the amount of white blood cells they have. Pneumonia from CMV mainly happens to people who were already infected with CMV, or whose donor had the virus. If neither you nor your donor had CMV, the transplant team might follow special precautions to prevent this infection while you are in the hospital.

After engraftment, the risk of infection is lower, but it still can happen. It can take 6 months to a year after transplant for the immune system to work as well as it should. It can take even longer for patients with graft-versus-host disease (GVHD, see below). It's important to talk to your cancer care team about your risk for infection during this time.

Because of the increased risk, you will be watched closely for signs of infection, such as fever, cough, shortness of breath, or diarrhea. Your doctor may check your blood often, and extra precautions will be needed to keep you from being exposed to germs. While in the hospital, everyone who enters your room must wash their hands well. They may also wear gowns, shoe coverings, gloves, and masks.

Since flowers and plants can carry bacteria and fungi, they're not allowed in your room. For the same reason, you may be told not to eat certain fresh fruits and vegetables. All your food must be well cooked and handled very carefully by you and family members. You might need to avoid certain foods for a while.

You may also be told to avoid contact with soil, feces (stool, both human and animal), aquariums, reptiles, and exotic pets. Your team may tell you to avoid being near disturbed soil, bird droppings, or mold. You will need to wash your hands after touching pets[4]. Your family may need to move the cat's litter box away from places you eat or spend your time. Also, you should not clean pet cages or litter boxes during this time. Instead, give this task to a family member or friend.

Your transplant team will tell you and your family in detail about the precautions[5] you

need to follow. There are many viruses, bacteria, and fungi that can cause infection after your transplant. You may be at risk for some more than others.

Despite all these precautions, patients often develop fevers, one of the first signs of

hospital to watch for pneumonitis as well as pneumonia. Some doctors will do breathing tests every few months if you have graft-versus-host disease (see next section).

You should report any shortness of breath or changes in your breathing to your doctor or transplant team right away. There are many other types of lung and breathing problems that also need to be handled quickly.

Graft-versus-host disease

Graft-versus-host disease (GVHD) can happen in allogeneic transplants when the immune cells from the donor see your body as foreign. (Remember: The recipient's immune system has mostly been destroyed by conditioning treatment and cannot fight back, so the new stem cells make up most of the immune system after transplant.) The donor immune cells may attack certain organs, most often the skin, gastrointestinal (GI) tract, and liver. This can change the way the organs work and increase the chances of infection.

GVHD reactions are very common and can range from barely noticeable to life-threatening. Doctors think of GVHD as acute or chronic. Acute GVHD starts soon after transplant and lasts a short time. Chronic GVHD starts later and lasts a long time. A person could have one, both, or neither type of GVHD.

Acute GVHD

- Weight loss

Doctors try to prevent acute GVHD by giving drugs that suppress the immune system, such as steroids (glucocorticoids), methotrexate, cyclosporine, tacrolimus, or certain monoclonal antibodies. These drugs are given before acute GVHD starts and can help prevent serious GVHD. Still, mild GVHD will almost always happen in allogeneic transplant patients. Other drugs are being tested in different combinations for GVHD prevention.

The risk of acute GVHD can also be lowered by removing immune cells called T-cells from the donor stem cells before the transplant. But this can also increase the risk of viral infection, leukemia relapse, and graft failure (which is discussed later). Researchers are looking at new ways to remove only certain cells, called **alloactivated T-cells**, from donor grafts. This would reduce the severity of GVHD and still let the donor T-cells destroy any cancer cells left.

If acute GVHD does occur, it is most often mild, mainly affecting the skin. But sometimes it can be more serious, or even life-threatening.

Mild cases can often be treated with a steroid drug applied to the skin (topically) as an ointment, cream, or lotion, or with other skin treatments. More serious cases of GVHD might need to be treated with a steroid drug taken as a pill or injected into a vein. If steroids aren't effective, other drugs that affect the immune system can be used.

Chronic GVHD

Chronic GVHD can start anywhere from about 90 to 600 days after the stem cell transplant. A rash on the palms of the hands or the soles of the feet is often the earliest sign. The rash can spread and is usually itchy and dry. In severe cases, the skin may blister and peel, like a bad sunburn. A fever may also develop. Other symptoms of chronic GVHD can include:

- Decreased appetite
- Diarrhea
- Abdominal (belly) cramps
- Weight loss
- Yellowing of the skin and eyes (jaundice)
- Enlarged liver
- Bloated abdomen (belly)
- Pain in the upper right part of the abdomen (belly)

- Increased levels of liver enzymes in the blood (seen on blood tests)
- Skin that feels tight
- Dry, burning eyes
- Dryness or painful sores in the mouth
- Burning sensations when eating acidic foods
- Bacterial infections
- Blockages in the smaller airways of the lungs

Chronic GVHD is treated with medicines that suppress the immune system, much like those used for acute GVHD. These drugs can increase your risk of infection for as long as you are treated for GVHD. Most patients with chronic GVHD can stop the immunosuppressive drugs after their symptoms improve.

Hepatic veno-occlusive disease (VOD)

Hepatic veno-occlusive disease (VOD) is a serious problem in which tiny veins and other blood vessels inside the liver become blocked. It’s not common, and it only happens in people with allogeneic transplants, and mainly in those who got the drugs busulfan or melphalan as part of conditioning, or treatment that was given before the transplant.

VOD usually happens within about 3 weeks after transplant. It’s more common in older people who had liver problems before the transplant, and in those with acute GVHD. It starts with yellowing skin and eyes, dark urine, tenderness below the right ribs (this is where the liver is), and quick weight gain (mostly from fluid that bloats the belly). It is life-threatening, so early diagnosis of VOD is very important. Researchers continue to find ways to try to measure a person's chances of getting VOD so that treatment can start as soon as possible.

V ver become b0tps more common in older

peripheral blood transplant, or within 7 weeks of a cord blood transplant.

Although it can be very upsetting to have this happen, these people can get treated with

of life.

Cancer that comes back

The goal of a stem cell transplant in cancer is to prolong life and, in many cases, even cure the cancer. But in some cases, the cancer comes back (sometimes called relapse or recurrence depending on when it might occur after a transplant). Relapse or recurrence can happen a few months to a few years after transplant. It happens much more rarely 5 or more years after transplant.

If cancer comes back, treatment options are often quite limited. A lot depends on your overall health at that point, and whether the type of cancer you have responds well to drug treatment. Treatment for those who are otherwise healthy and strong may include chemotherapy[7] or targeted therapy[8]. Some patients who have had allogeneic transplants may be helped by getting white blood cells from the same donor (this is called **donor lymphocyte infusion**) to boost the graft-versus-cancer effect. Sometimes a second transplant is possible. But most of these treatments pose serious risks even to healthier patients, so those who are frail, older, or have chronic health problems are often unable to have them.

Other options may include palliative (comfort) care[9], or a clinical trial[10]of an investigational treatment. It's important to know what the expected outcome of any further treatment might be, so talk with your doctor about the purpose of the treatment. Be sure you understand the benefits and risks before you decide.

Second cancers (new cancers caused by treatment)

Along with the possibility of the original cancer coming back (relapse) after it was treated with a stem cell transplant, there is also a chance of having a second cancer[11] after transplant. Studies have shown that people who have had allogeneic transplants have a higher risk of second cancer than people who got a different type of stem cell transplant.

A cancer called post-transplant lymphoproliferative disease (PTLD), if it occurs, usually develops within the first year after the transplant. Other conditions and cancers that can happen are solid tumor cancers in different organs, leukemia, and myelodysplastic syndromes. These other conditions, if they occur, tend to develop a few years or longer after the transplant.

Risk factors for developing a second cancer are being studied and may include:

- Radiation (such as total body irradiation) and high-dose chemo as part of the conditioning treatment
- Previous chemo or radiation treatment that was not part of the transplant process; the younger a person is when radiation is given, the more that person is at risk for certain types of cancer.
- Immune system problems (such as graft-versus-host disease, HLA-mismatched allogeneic transplant, and immunosuppressant therapy)
- Infection with viruses such as Epstein-Barr (EBV), cytomegalovirus (CMV), hepatitis B (HBV), or hepatitis C (HCV)
- The type of cancer you received the transplant for: for people who had their transplant when younger than 30 years old, those who had certain leukemias had a higher risk of having another cancer than people who did not have these leukemias.

Successfully treating a first cancer gives a second cancer time (and the chance) to develop. No matter what type of cancer is treated, and even without the high doses used for transplant, treatments like radiation and chemo can lead to a second cancer in the future.

Post-transplant lymphoproliferative disorder

Post-transplant lymphoproliferative disorder (PTLD) is an out-of-control growth of lymph cells, actually a type of lymphoma, that can develop after an allogeneic stem cell transplant. It's linked to T-cells (a type of white blood cell that is part of the immune system) and the presence of Epstein-Barr virus (EBV). T-cells normally help rid the body of cells that contain viruses. When the T-cells aren't working well, EBV-infected B-lymphocytes (a type of white blood cell) can grow and multiply. Most people are infected with EBV at some time during their lives, but the infection is controlled by a healthy immune system. The pre-transplant treatment given weakens the immune system, allowing the EBV infection to get out of control, which can lead to a PTLD.

Still, PTLD after allogeneic stem cell transplant is fairly rare. It most often develops within 1 to 6 months after allogeneic stem cell transplant, when the immune system is still very weak.

PTLD is life-threatening. It may show up as lymph node swelling, fever, and chills. There's no one standard treatment, but it's often treated by cutting back on immunosuppressant drugs to let the patient's immune system fight back. Other treatments include white blood cell (lymphocyte) transfusions to boost the immune response, using drugs like rituximab to kill the B cells, and giving anti-viral drugs to treat the EBV.

Even though PTLD doesn’t often happen after transplant, it’s more likely to occur with less well-matched donors and when strong suppression of the immune system is needed. Studies are being done to identify risk factors for PTLD and look for ways to prevent it in transplant patients who are at risk.

treatment.html
5. www.cancer.org/cancer/survivorship/coping/nutrition/weak-immune-system.html
6. www.cancer.org/cancer/managing-cancer/treatment-types/blood-transfusion-and-donation.html
7. www.cancer.org/cancer/managing-cancer/treatment-types/chemotherapy.html
8. www.cancer.org/cancer/managing-cancer/treatment-types/targeted-therapy.html
9. www.cancer.org/cancer/managing-cancer/palliative-care.html
10. www.cancer.org/cancer/managing-cancer/making-treatment-decisions/clinical-trials.html
11. www.cancer.org/cancer/survivorship/long-term-health-concerns/second-cancers-in-adults.html
12. www.cancer.org/cancer/managing-cancer/side-effects/fertility-and-sexual-side-effects.html

References

American Society of Clinical Oncology (ASCO). Side effects of a bone marrow transplant (stem cell transplant). Accessed at cancer.net. Content is no longer available.

Nathan S, Ustun C. Complications of stem cell transplantation that affect infections in stem cell transplant recipients, with analogies to patients with hematologic malignancies. *Infect Dis Clin North Am*. 2019; 33(2):331-359.

National Institutes of Health (NIH). Stem cell basics. 2016. Access at

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