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Bone Marrow Transplant

***Also known as a BMT, stem cell transplant, or hematopoietic stem cell transplant***

Bone marrow is found in the center of bones and is whereblood cells are made. It is found in the spongy part of the bones, especially the hips, ribs, breastbone, and spine. Bone marrow contains the youngest type of blood cells known as hematopoietic stem cells. As a hematopoietic stemcell ages, it becomes a white cell, red cell, or platelet. Hematopoietic stem cells are found in bone marrow,peripheral blood (bloodstream), and umbilical cord blood.

A bone marrow transplant (BMT) replaces diseased or damaged cells with non-cancerous stem cells that can grow healthy, new cells. BMT is usually used when cancertreatments have destroyed normal stem cells in the bone marrow. The stem cells can be replaced through BMT. A BMT is also performed when the chances for cure with[chemotherapy](http://curesearch.org/Chemotherapy-in-Children) alone are low.

Types of Bone Marrow Transplant (BMT)

There are two major types of BMT, and the type that your child will receive depends upon the diagnosis.

* **Allogeneic:** An allogeneic transplant is performed when bone marrow or blood cells are received from a donor other than the patient. These can come from a related donor, unrelated donor, or cord blood. This type of transplant is used for patients with [leukemias](http://curesearch.org/Leukemia-in-Children) and some [lymphomas](http://curesearch.org/Lymphoma-in-Children).
* **Autologous**: An autologous transplant is performed when the patient’s own bone marrow or blood cells are used. The marrow or cells are collected and frozen, and then thawed when needed for reinfusion. This type of transplant is used for patients with solid tumors such as [neuroblastoma](http://curesearch.org/Neuroblastoma-in-Children), [Hodgkin disease](http://curesearch.org/Hodgkin-Lymphoma-in-Children), and [brain tumors](http://curesearch.org/Brain-Tumors-in-Children).

Obtaining Bone Marrow Cells

***Allogeneic BMT***

The first step is to locate a donor whose blood cells closely match the patient’s. This is done by tissue typing prospective donors. Tissue typing is done by a blood sample and is called HLA typing, which stands for Human Lymphocyte Antigens. These antigens are found on the surface of white blood cells. A patient’s full siblings each have a 25% chance of being a tissue type match. Less commonly, a parent may match the patient. Occasionally, a less- than-perfectly matched related donor is used.

If a related donor is not available, then a search for a compatible, unrelated donor is performed through the National Marrow Donor Program. Unrelated donor cells can come from a living donor or frozen cord blood. Your physician will decide what the best source for donor cells is for your child. This is based upon urgency of the transplant, weight of your child, and the best tissue type match. An unrelated donor search may take several months; cord blood can be obtained within a few weeks.

***Autologous BMT***

Peripheral stem cells are usually collected for autologous transplant, but stem cells from the bone marrow also can be used. These are collected either before the patient has chemotherapy or following a course of chemotherapy. To collect peripheral stem cells, the patient receives medications (such as G-CSF and/or GM-CSF) to increase the number of peripheral blood stem cells available.

Cells are collected through a process called apheresis. An apheresis machine has a circuit that will collect blood, separate, and remove white blood cells containing stem cells, and then return red blood cells to the patient. This process takes about 4 hours and may need to be repeated for 2 or 3 days in a row. For certain diseases, the peripheral blood stem cells may be treated with anticancer medications to prevent tumor cells from being placed into back into the patient’s body.

Performing a Bone Marrow Transplant

***Before the transplant admission:***

When the healthcare team decides that BMT is the best treatment option for your child, they will schedule a lengthy conversation with you to explain the procedure. They will explain the many risks associated with BMT, as well as what you can expect before, during, and after the transplant.

Your child will undergo testing to make sure he/she is healthy enough to withstand the rigors of transplant. Testing will include evaluation of the heart function with electrocardiogram (ECG) and kidney and liver function, and infection status. Depending upon the disease, a [bone marrow aspirate](http://curesearch.org/Bone-Marrow-Aspirate/) and [spinal tap](http://curesearch.org/Lumbar-Puncture) may be performed.

When your child is deemed healthy enough for BMT, physicians will usually insert a [central line](http://curesearch.org/Central-Lines) catheter that allows easy access to a large vein in the chest. The catheter will be used to deliver the new stem cells, as well as blood, antibiotics, and other medications during treatment.

***Preparation Before Transplant:***

Your child will be given preparative treatment, called “conditioning” before the transplant. Conditioning includes high doses of chemotherapy and sometimes, [radiation](http://curesearch.org/Radiation-for-Kids) of the whole body. The type and purpose of conditioning depends upon your child’s underlying diagnosis but may include:

* Elimination of the cancer
* Making space in the bone marrow for new cells to grow
* Suppression of the immune system so that new cells may be accepted

Commonly used drugs include:

* Cyclophosphamide
* Melphalan
* Busulfan
* Etoposide
* Thiotepa
* Carboplatin

***The Transplant***

Once conditioning is complete, stem cells are given through a catheter. This is very similar to a blood transfusion. After traveling through the bloodstream to the bone marrow, the transplanted stem cells will begin to make red and white blood cells, and platelets.

It can take between 14 and 30 days for enough blood cells, particularly white blood cells, to be created so the body can fight infection. The identification of new blood cells and an increase in white blood cells following BMT is called engraftment. Until then, your child will be at a high risk for infection, anemia, and bleeding. Your child will remain in the hospital until he or she is well enough for discharge.

Tips for Parents

Outpatient follow-up is essential after discharge, as the risk of infection and other complications persist. Although the risk of [relapse](http://curesearch.org/Relapse-or-Recurrence/)(recurrence of the cancer) is less with a transplant than chemotherapy, relapse may still occur. Most relapses occur within several years after a transplant.

Why Are There Side Effects of Bone Marrow Transplant?

The process of BMT places a tremendous amount of strain on the body during conditioning, the actual transplant, and in the days following transplant. Your child’s immune system will basically be eliminated during conditioning. As a result, your child will be at high risk for infection and blood-related side effects immediately following transplant. Careful monitoring, use of medicines to treat or prevent infections, and other forms of supportive care can help your child to feel as comfortable as possible.

Common, Immediate Side Effects

**Infection** is very common before, during, and after transplant.

**Anemia (low red blood cells)** and thrombocytopenia (low platelets). Transfusions of red blood cells and platelets will be needed until the new cells increase sufficiently to make these.

**Mucositis** (sore mouth, sore throat). IV fluids or nutrition and pain medicines are used to help with these symptoms. This problem usually improves as the new cells grow in the patient.

**Loss of appetite, nausea**. IV nutrition and/or nutrition with a tube into the stomach are used so that weight loss doesn’t occur. Medications can be given to prevent or reduce nausea.

Long-term Risks

**Infection –** The patient’s immune system is destroyed after a transplant, and it takes many months and sometimes years to return. The types of infections that may occur include: bacterial, fungal, and viral. Preventive antibiotics are given for some patients. Special precautions are taken to protect your child from infection, including limiting visitors and avoiding crowded areas (such as stores) after discharge.

**Graft vs. host disease (GVHD)** – This occurs only in an allogeneic blood or marrow transplant. Certain types of donor cells, called T cells (or T lymphocytes) react to the patient’s body and recognize it as “foreign.” Medicines are given post-transplant to prevent this complication, but it may occur despite this.

* **Acute graft vs. host disease** – most commonly occurs within 3 months of transplant. The skin, liver, and intestines may be affected. Skin involvement occurs as a red rash that may be itchy or develop blisters. Liver involvement may causejaundice or elevation of other liver tests. Intestinal involvement may cause very severe, watery diarrhea. Medicines such as steroids are used to treat GVHD and are often successful in controlling it.
* **Chronic graft vs. host disease** – may occur months or even years after the transplant. Most commonly it is a continuation of acute GVHD. Many different parts of the body may be affected. Skin is the most common organ affected – patients may have red, scaly skin or skin that is thickened and tough. There may also be changes in the lining of the mouth, dry eyes, dry mouth, joint stiffness, lung restriction, and difficulty absorbing nutrients from foods. In addition, patients are at risk for infection because of the medications needed to control the GVHD as well as the effect of GVHD upon the immune system.

**Organ toxicity –** Conditioning and prior cancer treatment may damage the lungs, liver, kidneys, and heart. These effects are unpredictable and not all children recover from organ toxicity.

**Late Effects –** There is a very good chance that there will be [long-term effects](http://curesearch.org/Late-Effects-of-Treatment-for-Childhood-Cancer/) following BMT that may not be identified until years after treatment. These include:

* **Growth**and other endocrine (gland) problems may develop depending upon the type of conditioning used.
* **Sterility** is common for most patients.
* **Organ Damage** can occur to the liver, kidneys, lungs, or heart.
* **Cataracts** may develop clouding the lens of the eye and reducing vision.

## [Amazing Samples: Bone Marrow](http://blog.fisherbioservices.com/amazing-samples-bone-marrow)

## Posted by [Jaydeb Mukherjee](http://blog.fisherbioservices.com/author/jaydeb-mukherjee) on Oct 29, 2015 10:30:00 AM

When I was young, my father tried to teach me to eat everything put on my plate (though it was an uphill battle, since I was quite the finicky child). One of the few “bizarre” foods that I took a liking to, though, was sucking the marrow out of goat, lamb, or beef curries (my father was clearly not a devout Hindu). Even now, it’s one of my favorite parts of such dishes, and I recently added San Diego to my travel wish list if just to eat swordfish marrow ([thanks for the tip, Andrew Zimmern](http://catalinaop.com/fish-market/our-fishmonger/)).

But that’s clearly not what we’re going to talk about right now. Everyone knows that human bone marrow is rich in stem cells, specifically hematopoietic. In fact, without research on bone marrow, stem cells might not be as well understood, and accordingly we might not have reached the current burgeoning development in the cell therapy field. Last time in our Amazing Samples blog series, we discussed the value of adipose tissue cells. This time, let’s savor the rich history of bone marrow research.

… Man, I should cook some curry.

**Hematopoietic Cell Transplantation**

Today, even children taking early biology classes learn that bone marrow’s primary function is to produce blood, and that description is quickly being expanded to include other produced cell types (from mesenchymal stem cells). It’s only been in the past century that science has developed to the point of understanding such things, and just in time – while recently-discovered nuclear radiation was shown to kill cancer cells, the required levels also inflicted lethal damage on the healthy bone marrow of those exposed. Two doctors pioneered the technique of transplanting the bone marrow, replacing the damaged tissue with healthy hematopoietic cells from a donor.

 The first bone marrow transplantation is credited to Dr. Donnall Thomas, who in the late 1950’s ended up [curing a patient of acute lymphocytic leukemia](http://www.washington.edu/research/pathbreakers/1955a.html) by following the radiotherapy with a bone marrow transplant from the patient’s twin (called syngeneic). Shortly thereafter [Dr. George Mathé](http://www.nytimes.com/2010/10/21/health/research/21mathe.html) in France performed the first non-twin bone marrow transplants, showing that allogeneic transplants were possible with the proper technique – good news for everyone who didn’t have a twin.

Today, a number of techniques can be used to help to replenish a chemotherapy or radiotherapy patient’s bone marrow after treatment. If the patient’s bone marrow is relatively free of cancer cells, they can prepare an autologous transplantation – procuring the patient’s own marrow and [cryopreserving](http://blog.fisherbioservices.com/the-other-glass-ceiling-maintaining-cell-therapies-at-135c) it until the patient is ready for a transplant. Should the patient’s marrow not be appropriate for re-transplantation, then a compatible donor must be found for an allogeneic implant. In fact, past the benefit of replacing the damaged marrow, healthy marrow can even help fight against certain cancers while in remission, with the graft-generated immune cells actively attacking the damaged cancer cells, and it is being investigated for a number of autoimmune indications as well. See the [NCI’s Stem Cell Fact Sheet](http://www.cancer.gov/about-cancer/treatment/types/stem-cell-transplant/stem-cell-fact-sheet) for more information, and if you’re willing to donate your bone marrow or related cells to help someone with their cancer treatment, here are a few different organizations, depending on your location:

* The [US Health Resources and Services Administration](http://bloodcell.transplant.hrsa.gov/donor/donating/donation_faqs/) specifically names the C.W. Bill Young Cell Transplantation Program, aka[Be The Match Registry](https://bethematch.org/support-the-cause/donate-bone-marrow/donation-process/donating-bone-marrow/), as the national registry.
* DKMS, or [Delete Blood Cancer](http://www.deletebloodcancer.org/en/Faq), also operates in the UK, Germany, Poland, and Spain.

**Why Kill What You Can Convert?**

[In surprising research just published last week](http://www.pnas.org/content/early/2015/10/20/1519079112), it turns out that exposing malignant marrow cells to a certain agonist antibody not only transforms them back into benign cells, but specifically into natural killer (NK) cells that singularly target still-malignant cells. Cancer research has been looking for techniques to do the first step – after all, converting cancer cells back into healthy tissue would eliminate many of the traditional dangers and collateral damage from chemotherapy (such as the damaging of bone marrow).

Richard Lerner et al at the Scripps Institute have been researching cell transformation for a few years, and just two years ago had already discovered that healthy bone marrow stem cells could be [transformed—transdifferentiated—into a brain progenitor cell](https://www.scripps.edu/newsandviews/e_20130429/lerner.html), with but a single protein. They were expanding their research when they discovered that not only could this single antibody convert leukemia cells into healthy tissue without affecting healthy marrow cells, but a certain number of them turned into high-specificity NK cells that only attack their malignant former brethren. While obviously this single facet of the discovery only shows the antibody’s value against leukemia, imagine the possibilities if it were shown to have a similar effect on other types of cancer.

**Bone Marrow on a Chip**

I’m not talking about a bizarre snack food. The use of microfluidic devices, or organ-on-a-chip technology, is a [bioengineering trend to enable higher efficiency and throughput in research at lower costs](http://www.sciencedirect.com/science/article/pii/S0167779914000870), and just last year Harvard’s Wyss Institute for Biologically Inspired Engineering managed to [accurately reproduce bone marrow in this form](http://wyss.harvard.edu/viewpressrelease/153). The marrow-on-a-chip even maintains function similar to *in vivo* marrow, with stem cells in similar proportions for up to 1 week.

This greatly increases the viability of any research of bone marrow responses to new therapies, as well as the general research into the stem cells found inside. See the [Wyss Institute’s video](http://wyss.harvard.edu/viewpressrelease/153) for more information!

Even if marrow isn't the most popular food for all people, its scientific value is undeniable. Whether spearheading transplant medicine or being used for new applications in oncology, bone marrow cells are an Amazing Sample.