



PROVIDING THE LATEST INFORMATION  
FOR PATIENTS & CAREGIVERS

# Myeloma



Revised **2023**

---

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

---

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, and optimism. Finding 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

## Inside This Booklet

- 2** Introduction
- 2** Myeloma Basics
- 3** Signs and Symptoms
- 6** Diagnosis
- 15** Staging and Prognostic Factors
- 17** Treatment Options
- 34** Measuring Treatment Response
- 37** Treatment Options for Relapsed and Refractory Disease
- 39** Clinical Trials for Blood Cancers
- 41** Complications, Side Effects and Supportive Care
- 46** Financial Concerns
- 47** Follow-Up Care
- 48** Related Diseases
- 51** Incidence, Causes and Risk Factors
- 53** Normal Blood and Bone Marrow
- 55** Resources and Information
- 59** Health Terms
- 71** References

### Acknowledgement

The Leukemia & Lymphoma Society appreciates the review of this material by:

#### **Marc Braunstein, MD, PhD, FACP**

Assistant Professor of Medicine

Program Director, Hematology/Oncology Fellowship

Co-Director Hematology Organ System

NYU Long Island School of Medicine

Perlmutter Cancer Center at NYU Langone Hematology Oncology Associates—Mineola

NYU Langone Hospital—Long Island

Mineola, NY

Support for this publication provided by Bristol Myers Squibb; Genentech, A Member of The Roche Group; GSK plc; Karyopharm Therapeutics; Sanofi US.

This publication is designed to provide accurate and authoritative information about the subject matter covered. It is distributed as a public service by The Leukemia & Lymphoma Society (LLS), with the understanding that LLS is not engaged in rendering medical or other professional services. LLS carefully reviews content for accuracy and confirms that all diagnostic and therapeutic options are presented in a fair and balanced manner without particular bias to any one option.

# Introduction

Myeloma is a cancer of plasma cells. A plasma cell is a type of white blood cell found in the bone marrow. Brief descriptions of blood and bone marrow in normal conditions are provided on pages 53 and 54. A section with definitions of health terms related to myeloma begins on page 59.

An estimated 34,470 people living in the United States were expected to be diagnosed with myeloma in 2022.<sup>1</sup> Myeloma is incurable in most cases; nevertheless, this is a very hopeful time for patients. Over the past decade, dramatic advancements in understanding the disease and developing new treatment approaches are improving the overall survival rate, allowing many patients to maintain a good quality of life for years. In 2021 there were an estimated 147,663 people either living with or in remission from myeloma.<sup>1</sup>

This progress in managing myeloma is expected to continue because of the concerted scientific research effort under way and because of patients' participation in clinical trials, with the goal of finding a cure. New treatment approaches for myeloma are being studied in clinical trials for patients of all ages and at all stages of the disease.

**Visit [www.LLS.org/booklets](http://www.LLS.org/booklets) to view, download or order all free LLS publications mentioned in this booklet.**

**Feedback.** Visit [www.LLS.org/PublicationFeedback](http://www.LLS.org/PublicationFeedback) to give suggestions about this booklet.

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

<sup>1</sup>Source: Cancer Facts & Figures, 2022. American Cancer Society; 2022. SEER\*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute. [Cited 2021 September 27]. Available from <https://seer.cancer.gov/explorer/>.

## Myeloma Basics

Myeloma is a cancer of plasma cells. It is part of a group of disorders known as “plasma cell dyscrasias” or “plasma cell neoplasms.” B lymphocytes (B cells) are a type of white blood cell that normally develops into a plasma cell; B cells are found in the blood, lymph nodes and bone marrow. Healthy plasma cells are part of the immune system and make types of protein, called “antibodies,” or “immunoglobulins,” which help fight infections. Multiple myeloma affects Black individuals twice as commonly as Whites and affects males about twice as frequently as it does females. The median age of diagnosis is 69 years.

In myeloma, one or more acquired genetic mutations in a plasma cell leads it to become cancerous. This malignant plasma cell multiplies into many malignant plasma cells that take up space in the healthy bone marrow. Eventually, this process can lead to crowding of the bone marrow and impair the production of normal white blood cells, red blood cells and platelets. This process can also lead to the formation of lytic bone lesions (see *Effects on Bone* on page 4) caused by malignant plasma cells invading the bone marrow. The malignant plasma cells (also called “myeloma cells”) produce abnormal proteins that resemble normal antibodies, but no longer have protective antibody properties. Occasionally, these proteins may form into amyloid (an abnormal protein made by malignant plasma cells), which deposits and accumulates in different tissues and can damage the kidneys, heart, or other organs and affect immune system function.

While the malignant plasma cells are most commonly found in the bone marrow, they may accumulate in any part of the body. These accumulations are known as “plasmacytomas” and most commonly occur in the bones, skin, muscle or lungs. If the malignant cells form a single tumor without disease elsewhere in the body, it is called a “solitary plasmacytoma.” The plasmacytoma can often be cured with radiation therapy alone, although it may recur or later develop into multiple myeloma.

In most patients with myeloma, the disease already involves multiple sites at the time of diagnosis. Because of this, the term “multiple myeloma” or “symptomatic myeloma” is often used to refer to the disease in its most common form.

Asymptomatic myeloma is also referred to as “smoldering myeloma” or “MGUS” (monoclonal gammopathy of uncertain significance). These are slow-growing types of myeloma in which malignant plasma cells produce too much of an abnormal antibody. Usually there are no symptoms at diagnosis, so asymptomatic myeloma requires monitoring but no treatment. Some patients with asymptomatic myeloma may have a higher risk of progression to active myeloma than others. So, patients with smoldering myeloma need to be checked often for signs and/or symptoms of progression to fully developed, active myeloma that requires treatment. Talk to your doctor to find out more about clinical trials that may be available for patients who have high-risk smoldering myeloma.

## Signs and Symptoms

In the early stages of myeloma, some patients have no signs and/or symptoms of the disease. It is sometimes detected before symptoms appear, when results of laboratory tests done as part of a routine medical examination show abnormalities in the blood and/or urine, or imaging studies incidentally show a bone lesion. When symptoms are present, the most common ones are bone pain and fatigue.

Doctors sometimes refer to the acronym **CRAB** to describe signs and/or symptoms of myeloma. The letters stand for the following criteria:

- C** for calcium elevation (a high level of calcium in the blood, also known as “hypercalcemia”)
- R** for renal dysfunction (poor kidney function that may be due to deposits of monoclonal antibody proteins in the kidneys)
- A** for anemia (low red blood cell count)
- B** for bone abnormalities (lesions)

Patients with one or more of the CRAB signs and/or symptoms, along with at least 10 percent of the bone marrow occupied by malignant plasma cells, as seen on a bone marrow biopsy test, are considered to have active (symptomatic) myeloma that requires treatment (see *Treatment Options* beginning on page 17 for more information). Having 60 percent malignant plasma cells in the bone marrow, but no CRAB signs and/or symptoms, is also diagnostic of myeloma since these patients are at high risk for developing organ damage.

**Effects on Bone.** Normally, bones are constantly remodeling, maintaining a balance between bone destruction and formation. In strong and healthy bones, osteoclasts (bone-destroying cells) and osteoblasts (bone-building cells) work together in the continuous well-balanced process called “bone remodeling” (the process of reabsorption of old bone and formation of new bone). This process becomes unbalanced in patients with myeloma. Myeloma cells release substances that cause an imbalance, with greater bone destruction and less new bone formation. This may result in bone thinning (osteoporosis) or holes in the bones (lytic lesions). Without treatment, bones with larger lesions may break easily from activities as simple as coughing. The pain is usually constant and made worse by movement. Bone lesions are present in about 80 percent of myeloma patients, most commonly in the skull, collarbone, ribs, back and pelvis, but any bone may be affected. Bone lesions are not usually found in joints.

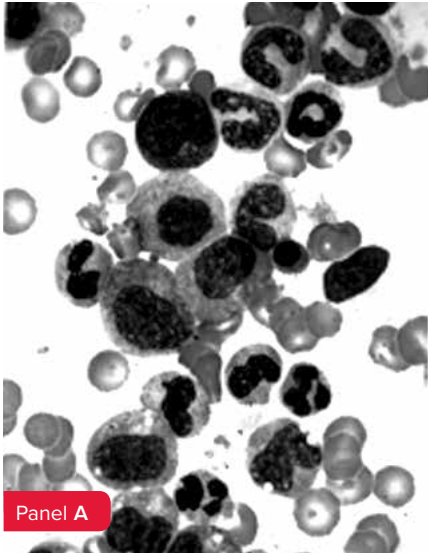
When more bone destruction than bone formation occurs, calcium may be released into the blood. If the level becomes too high, patients may experience symptoms such as confusion, elevated blood pressure, nausea and/or vomiting, constipation and excessive thirst.

**Effects on Blood and Bone Marrow.** The bone marrow normally produces blood cells that circulate through the body, such as red blood cells that carry oxygen, white blood cells that fight infection, or platelets that help prevent bleeding. Myeloma cells crowd out the normal bone marrow cells and accumulate in an uncontrolled manner in the bone marrow (see **Figure 1**). This results in lower-than-normal numbers of healthy blood cells. A decrease in the number of red blood cells or hemoglobin concentration is called “anemia,” and can cause

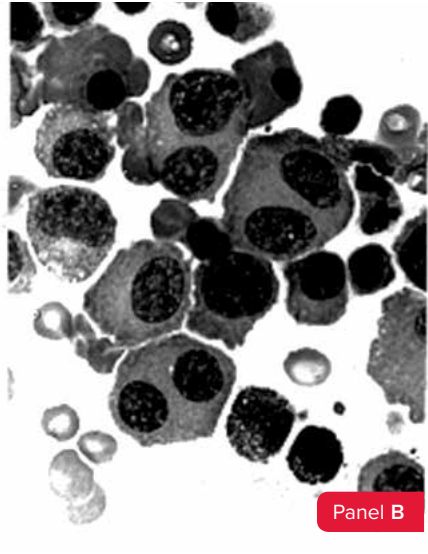
fatigue and/or a pale complexion. Anemia occurs in approximately 75 percent of myeloma patients. The number of white blood cells may also be decreased, resulting in recurrent infections, most commonly of the urinary or respiratory tract. The number of platelets is sometimes also low, resulting in easy bruising or bleeding.

### Figure 1. Normal Cells versus Myeloma Cells

Normal Cells



Myeloma Cells



**Panel A** is a photograph of normal marrow cells. The variations in the shape and appearance of the cells are characteristic of the developmental stages of normal cells. **Panel B** is a photograph of marrow cells from a patient with myeloma. The normal marrow cells are replaced by plasma cells. Several cells have two nuclei, which may be a sign of abnormal plasma cells (myeloma cells).

**Other Effects.** High levels of antibodies (types of protein) may be harmful to the kidneys. If these proteins are entering the urine, it may look foamy and the patient may notice swelling of the legs, excessive thirst and either an increase or decrease in the volume of urine produced every day.

An early symptom can be numbness, tingling, burning or pain in the hands and/or feet, a condition called “peripheral neuropathy,” caused when antibodies attack the nerves.

Abnormal protein deposition (buildup), a condition called “amyloidosis,” may occur in any part of the body, but most often in the heart and kidneys.

If antibody levels in the blood become too high, the blood may become thick

(viscous), resulting in “hyperviscosity syndrome.” This rarely occurs and is more common when the myeloma produces certain classes of antibodies, such as immunoglobulins types A or M. Signs and/or symptoms of hyperviscosity syndrome include abnormal bleeding, headaches, chest pain, decreased alertness and shortness of breath.

See *Complications, Side Effects and Supportive Care*, beginning on page 41, for more information.

## Diagnosis

An accurate diagnosis is one of the most important aspects of a person’s medical care. Obtaining a precise diagnosis will help the healthcare team to:

- Estimate how the disease will progress
- Determine the appropriate treatment

The results of blood tests that accompany periodic medical examinations may indicate the need for further evaluation for myeloma. These include an elevated protein level, anemia, kidney function or calcium level abnormalities.

**Diagnostic Criteria.** The diagnosis of myeloma is based on the following three findings:

- Malignant plasma cells. Test results must confirm the presence of a plasma cell level of more than 10 percent in a bone marrow biopsy sample, or any atypical plasma cells indicating a plasmacytoma. In addition, pathology tests may provide information about genetic abnormalities that helps to predict the risk of relapse. Biopsy of a specific organ, such as a kidney or the heart may be required if there is a suspicion that there could be amyloid buildup in specific organs.
- Unusually large amounts of monoclonal protein in blood and/or urine is referred to as the “M spike,” for monoclonal protein that is produced by the myeloma plasma cells. Monoclonal proteins can be either intact monoclonal immunoglobulins or immunoglobulin light chains (also called “Bence Jones proteins”) found in the blood and/or urine. See *Monoclonal Immunoglobulin (IgM): Monoclonal Protein (M Protein) and Light Chains (Bence Jones Proteins)* on page 7 and **Figure 2** on page 8.
- Evidence of end-organ damage, as defined by the CRAB (calcium elevation, renal dysfunction, anemia, bone abnormalities) criteria or the presence of amyloid on tissue biopsy (see **Table 1** on page 7). If there are no CRAB signs and/or symptoms, the presence of 60 percent plasma cells in the bone marrow is considered diagnostic.



In 2014, the International Myeloma Working Group (IMWG) updated the diagnostic criteria for myeloma to include biomarkers, in addition to the existing CRAB features. **Table 1** outlines the revised IMWG criteria for the diagnosis of myeloma.

**Table 1. Revised International Myeloma Working Group (IMWG) Criteria for the Diagnosis of Multiple Myeloma**

**Both of the following criteria must be met:**

- Malignant plasma cells in the bone marrow  $\geq 10\%$  or presence of bony or extramedullary plasmacytoma, confirmed by biopsy
- Any one or more of the following myeloma-defining events:
  - Evidence of end-organ damage that can be attributed to the disease: (CRAB criteria)
    - **Calcium elevation** — serum calcium  $>0.25$  mmol/L ( $>1$  mg/dL) higher than the upper limit of normal or  $>2.75$  mmol/L ( $>11$  mg/dL)
    - **Renal dysfunction** — creatinine clearance  $<40$  mL per minute or serum creatinine  $>177$   $\mu\text{mol/L}$  ( $>2$  mg/dL)
    - **Anemia** — hemoglobin concentration of  $>2$  g/dL below the lower limit of normal, or a hemoglobin concentration of  $<10$  g/dL
    - **Bone abnormalities (lesions)** — one or more osteolytic lesions found on x-ray views, CT or PET-CT scans
  - Clonal plasma cells in the bone marrow  $\geq 60\%$  with or without CRAB
  - Ratio of involved/uninvolved serum free light chain  $\geq 100$  (involved free light chain level must be  $\geq 100$  mg/L)
  - One or more focal lesions found on MRI studies (at least 5 mm in size)

**Key:** CT, computed tomography; dL, deciliter; IMWG, International Myeloma Working Group; L, liter; mg, milligram; mm, millimeters; mmol, millimole (a mole is an amount of a substance that contains a very large number of molecules or atoms; a millimole is one-thousandth of a mole); MRI, magnetic resonance imaging; osteolytic lesion, the dissolution of bone, especially the loss of calcium from bone; PET, positron emission tomography; PET-CT, positron emission tomography-computed tomography;  $\mu\text{mol}$ , micromole (one-millionth of a mole)

**Source:** Rajkumar SV. Multiple myeloma: 2022 update on diagnosis, risk stratification, and management. *American Journal of Hematology*. See *References* on page 71.

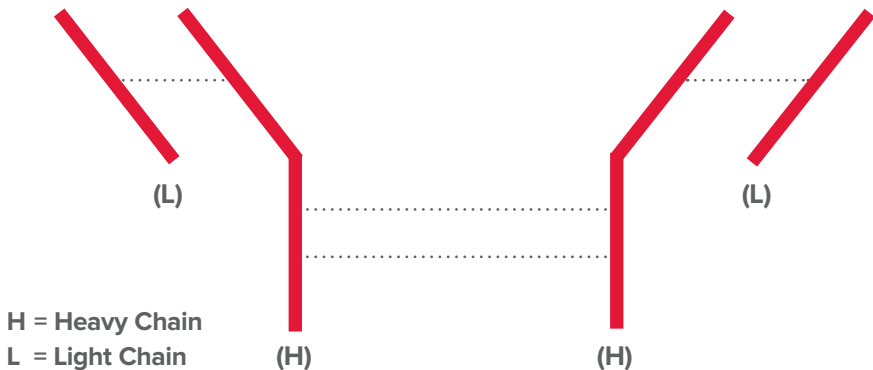
**Monoclonal Immunoglobulin (IgM): Monoclonal Protein (M Protein) and Light Chains (Bence Jones Proteins).** In healthy individuals, plasma cells normally produce proteins called “polyclonal immunoglobulins.” These are antibodies that protect the body against all kinds of different invading viruses, bacteria or other infectious agents (antigens).

In myeloma, large amounts of a single antibody are noted as a “monoclonal immunoglobulin spike” or as a “monoclonal spike” (M spike), indicating that the protein came from cells that originated from single, malignant cells. The level of M protein can be measured in blood and/or urine samples and generally correlates with the extent of the myeloma. The monoclonal protein is called a “spike” because of the way it appears on the protein electrophoresis laboratory test result (see *Protein Electrophoresis Tests* on page 9).

Increasing levels of monoclonal protein usually indicate progression of the disease and decreasing levels usually reflect response to treatment. A small number of patients have “oligosecretory myeloma,” in which there is a low level of monoclonal protein detected, or “nonsecretory myeloma,” in which no monoclonal protein can be detected. About 2 to 3 percent of patients have nonsecretory myeloma. In some of these patients only monoclonal light chains are produced, which are small pieces of the antibody. These are not always detected as an M spike. These patients can be monitored by measuring their level in urine specimens or with a blood test that measures the level of serum free light chains.

An intact immunoglobulin (Ig) molecule is composed of two larger pieces (heavy chains) and two smaller pieces (light chains) that are attached to each other. There are five types of heavy chains, and each type is represented by a specific letter: IgG, IgA, IgD, IgE and IgM. There are two types of light chains, referred to as “kappa (k)” and “lambda ( $\lambda$ ).” See **Figure 2**.

**Figure 2. Immunoglobulin Molecule**



The monoclonal protein in myeloma, like normal immunoglobulin, is made up of two heavy chains and two light chains attached to each other. In some myeloma patients, the coordinated process of making and attaching light chains and heavy chains fails in the malignant plasma cells. Unattached, “free” light chains enter the blood and are excreted rapidly in the urine, where they can be detected. Light chains in the urine are also referred to as “Bence Jones proteins.”

This whole (intact) immunoglobulin, made of the four chains, is usually too large to pass through the kidneys. So, it is most often present in the blood but not in the urine. When intact immunoglobulin is present in the urine, the level is usually low.

In many myeloma patients, the coordinated process of making and attaching light chains and heavy chains fails in the malignant plasma cells. Unattached, “free” light chains enter the blood and are excreted rapidly in the urine. The light chain is also called the “Bence Jones protein,” named for the English doctor Henry Bence Jones who studied its characteristics. When excreted in large amounts, Bence Jones proteins (free light chains) can sometimes make the urine appear foamy and can harm the kidneys (see *Urine Test* below).

Each plasma cell produces one of five types of antibodies: IgG, IgA, IgM, IgE or IgD, and either kappa or lambda. Myeloma cells produce many copies of its antibody. The most common type of myeloma is IgG kappa (occurring in approximately 52 percent of patients), in which the monoclonal protein is composed of two heavy chains and two light chains (see **Figure 2** on page 8). The next most common type is light chain myeloma, in which no intact immunoglobulin is produced. Some patients have the IgA type (about 21 percent of patients), and a small number of patients have the IgM type (about 0.5 percent of patients), the IgD type (about 2 percent of patients) or the IgE type of myeloma.

**Protein Electrophoresis Tests.** Serum protein electrophoresis (SPEP) and urine protein electrophoresis (UPEP) are tests in which proteins in blood and urine samples are separated so that individual antibodies can be identified and quantified. These tests are done in conjunction with immunofixation—for example, serum immunofixation electrophoresis (SIFE), which identifies immunoglobulins in blood samples. See page 69. All five types of immunoglobulins (IgG, IgA, IgM, IgE, and IgD) are measured by these tests. If present, an excessive production of a monoclonal immunoglobulin may be shown in laboratory test results as a spike on a graph (M spike). Most patients with untreated myeloma have a monoclonal immunoglobulin spike in serum, urine, or both.

**Serum Free Light Chain (SFLC) Assay.** Serum free light chain testing provides complementary information to the two protein electrophoresis tests: SPEP and UPEP. The SFLC assay can detect abnormal levels of free light chains, which may be an indication of a plasma cell disorder. It can also detect changes in the ratio of kappa and lambda light chain production, which indicates an excess of abnormal plasma cells.

### **Additional Diagnostic Tests**

**Urine Test.** In some patients, the myeloma cells do not make a complete monoclonal immunoglobulin molecule with two heavy and two light chains (see **Figure 2** on page 8). Instead, they only make light chains. In these cases of “light chain myeloma,” serum test results may not show the characteristic increase of M protein (M spike), but there may be large amounts of monoclonal light chains in the urine.

Testing a 24-hour urine sample allows for an accurate measurement of the level of kidney function and can indicate possible kidney damage from myeloma. When there is damage to the kidneys, other proteins, such as albumin, may also be present in the urine. Also, the level of protein being excreted in the urine and the amount of light chains can be measured. All of these measurements provide information about the extent of the disease and are useful for monitoring response to treatment.

**Complete Blood Count (CBC).** This test measures the numbers of red blood cells, white blood cells and platelets in the blood. These measurements indicate the degree to which the myeloma cells in the marrow are affecting normal blood cell development. Sometimes a CBC with differential (CBC with diff), a test that also measures the number of the different types of white blood cells present in the blood, is ordered.

**Blood Chemistry Tests.** Abnormal levels of certain chemicals may indicate that an organ is not working properly or they may be caused by cancer or other health conditions. Tests are done to measure the levels of the following substances in the blood:

- Blood urea nitrogen (BUN) is a waste product made by the liver that is filtered out of the blood and into the urine. This level must be monitored carefully in myeloma patients, since too much urea in the blood causes increased risk for developing kidney disease. A high BUN level may be a sign of kidney damage.
- A blood test is done to measure the level of calcium in the blood. Bone destruction causes calcium to leave the bones and enter the blood, where it may reach an elevated level. This can damage many organs, including the brain, nerves, muscles, gut and kidneys.
- Creatinine is a waste product from muscles that is also filtered out of the blood and into urine by the kidneys. A high creatinine level may be a sign of kidney damage.
- Glomerular filtration rate (GFR) is a test that calculates kidney function.
- Albumin is the main protein in blood plasma. A low level of this protein may be a sign of advanced myeloma, or indicate the presence of amyloidosis, malnutrition or chronic disease and inflammation.
- Total protein level is a measure of all the proteins in the blood, including the myeloma proteins. The level is often elevated on diagnosis and may go down with treatment, though it is not as specific as the SPEP to measure the myeloma proteins.
- Beta 2 ( $\beta_2$ )-microglobulin is a small protein made by many types of cells, especially B cells. A high level of  $\beta_2$ -microglobulin may be a sign of a high number of myeloma cells. The levels of this protein and albumin are

significant and will be considered when staging myeloma. The higher the number, the more likelihood of shorter survival.

- Lactate dehydrogenase (LDH) is a protein made by many different types of cells, including myeloma cells. A high LDH level may be an indication of advanced myeloma. This finding is also used in staging myeloma.
- Electrolytes such as sodium, calcium, potassium, and chloride are minerals needed for healthy organ function. When there is kidney damage, there may be abnormal levels of these chemicals.
- Uric acid is a chemical released when malignant cells die. Very high levels of uric acid in the blood can cause damage to the kidneys and other organs.
- Liver function tests measure the level of certain proteins and enzymes in the blood. Abnormal levels may indicate liver disease or damage.

**Flow Cytometry.** This is a test that determines whether abnormal plasma cells are present in a liquid sample of bone marrow aspirate or blood. Rarely, plasma cells can enter into the circulation and if they represent 20 percent or more of the blood cells, the condition is called “plasma cell leukemia.” Note that the percent of plasma cells in the bone marrow, assessed by flow cytometry, is not the value used in the diagnostic criteria above. That criteria is determined by a pathologist who reviews the bone marrow aspirate slides.

**Cytogenetic Analysis.** Fluorescence in situ hybridization (FISH) is a type of laboratory test that uses special dyes to identify mutations of specific chromosomes in cells. Chromosomal abnormalities play a crucial role in identifying cancerous cells and determining the risk of relapse. Approximately 40 percent of myeloma cases are characterized by the presence of trisomies (three copies of a chromosome) in the malignant plasma cells, while in most of the rest there is a translocation involving chromosome 14 (the site of a gene for the immunoglobulin heavy chain). A translocation is when part of one chromosome breaks off and switches places with part of another chromosome. A small number of patients have both trisomies and IgH translocations. While these common mutations can be found in myeloma, they often differ between patients, making myeloma a heterogenous disease (a medical condition with several root causes).

**Table 2**, on page 13, shows the most common cytogenetic abnormalities in myeloma. These abnormalities can indicate how rapidly the disease may progress and predict the chances of a long-lasting response to certain therapies. For instance, myeloma patients with trisomies may benefit from drug combinations that include immunomodulator drugs (IMiDs), while those with an IgH translocation may have better responses to treatment with proteasome inhibitors (PIs). These cytogenetic findings are used to classify myeloma as either “high risk” or “standard risk.” The presence of any two high-risk cytogenetic abnormalities is considered “double-hit myeloma.” When any three high-risk

abnormalities are present, this is known as “triple-hit myeloma.” The more high-risk features present, the more likely the disease is to relapse or fail to respond to treatment. Discuss with your healthcare team whether participating in a clinical trial is an appropriate option for you.

**Next-Generation Sequencing (NGS).** This is a broad term encompassing a number of modern technologies that increase the speed and reduce the cost of DNA (deoxyribonucleic acid) sequencing to look for mutations. With NGS, researchers can sequence DNA and RNA (ribonucleic acid) much more quickly and cost effectively than they could with older technologies. It identifies mutations present in the genes of the myeloma cells. Since the expression levels of these genes and how mutations in them, if present, influence the behavior of the myeloma cells, these techniques may be helpful in better predicting treatment outcomes and developing new and improved targeted therapies. Next-generation sequencing is being done now on a research basis but may soon be used in routine clinical practice. Note that both flow cytometry (described on page 11) and NGS can be used for another purpose (to look for signs and/or symptoms of residual disease after treatment, for example).

**Table 2. Most Common Cytogenetic Abnormalities in Myeloma**

Cytogenetic Abnormality	Frequency	Prognostic Risk and Additional Characteristics
MYC translocation	15%-20%	Standard or high
t(6;14) (p21;q32)	2%	Standard
t(11;14) (q13;q32)	15%-20%	Standard, sensitive to venetoclax
Hyperdiploidy	50%	Low, good response to lenalidomide in patients with trisomies
t(4;14) (p16;q32)	10%-15%	High, good response to proteasome inhibitors, unfavorable response to any immunomodulatory drug
t(14;16) (q32;q23)	2%-3%	High
t(14;20) (q32;q11)	1%	High
Hipodiploidy	13%-20%	High
13q del	45%-50%	High
1q21 gain	35%-40%	High, might be involved in bortezomib resistance
1p32del	30%	High
17p del	At diagnosis <10%, at relapses >30%	High, possible CNS involvement, pomalidomide treatment seems beneficial

Primary cytogenetic abnormalities are associated with the initial development of disease. Secondary cytogenetic abnormalities occur with disease progression.

**Key:** CNS, central nervous system; del, deletion; p, the short arm of a chromosome (the upper half); q, the long arm of a chromosome (the lower half); t, a translocation between chromosomes; trisomies, three copies of a chromosome instead of two.

**Sources:** Adapted from:

Goldman-Mazur S, Vesole DH, Jurczyszyn A. Clinical implications of cytogenetic and molecular aberrations in multiple myeloma. *Acta Haematologica Polonica*.

Rajkumar SV. Multiple myeloma: 2022 update on diagnosis, risk stratification, and management. *American Journal of Hematology*. See *References* on page 71.

**Imaging Tests.** The following imaging tests are a very important part of the diagnosis, staging and management of myeloma. Your doctor may order one or more of these tests to image the skeleton:

- **Bone/Skeletal Survey.** X-rays of all the bones in the body are taken and examined to identify areas of decreased bone density and bone lesions. This should not be confused with a bone scan which is not used to detect lytic bone lesions.
- **Magnetic Resonance Imaging (MRI) Scan.** This imaging test is done in select cases. It uses a powerful magnet to measure water and fat in the body. It is useful for detecting abnormalities in the bone marrow signal and the effects of disease on the spinal cord, known as “cord compression.” A whole-body MRI scan may be done when the skeletal survey does not show any signs of disease.
- **Whole Body Low-dose Computed Tomography (CT) Scan.** In CT scans, many pictures of different areas inside the body are taken from different angles using x-rays. A computer combines all the images to create a single, clear and detailed picture. The amount of radiation used for this scan is much lower than that used for standard CT scans.
- **Positron Emission Tomography and Computed Tomography (PET-CT) Scan.** A PET-CT scanner combines the techniques of both PET and CT in one machine. A single imaging session is all that is needed to produce a PET-CT scan that reveals information about both the structure and function of cells and tissues in the body. It provides a more detailed picture of where the cancer is located in the body than either test can by itself, and it is the only imaging test used to evaluate treatment response.

Certain imaging tests may be done depending on the situation. For example, MRI has been found to be a very sensitive method to evaluate bone involvement (for example, when looking for spinal cord compression); PET-CT is the most sensitive option for detection of extramedullary disease (when looking for a plasmacytoma); and a whole-body low-dose CT scan is preferred for its lower cost.

The latest clinical guidelines from the International Myeloma Working Group (IMWG) recommend replacing conventional skeletal survey with whole-body low-dose CT as the standard imaging technique for assessing bone lesions. Given that there must be significant bone destruction, sometimes up to 70 percent, before it can be visible on x-ray skeletal survey, more advanced techniques such as low-dose CT and PET-CT scans are recommended for disease staging and treatment monitoring.



## Questions to Ask Your Doctor About Testing:

- How was my diagnosis established?
- What tests are necessary before I start treatment?
- When will the tests take place?
- Where will the tests take place?
- How long will the tests take?
- Will my insurance provider pay for all my tests? If not, is there someone who can help me to find out how I can get the cost of my tests covered?
- What are my options if my insurance plan does not cover the cost of the tests that are needed?
- Will the tests need to be repeated after the end of the initial treatment?

## Staging and Prognostic Factors

Doctors use imaging and laboratory test results and bone marrow examination findings to determine the extent of disease. This determination is called “staging” and it provides important information for treatment planning and for prognosis. There is significant variation in myeloma patient outcomes, depending on a series of factors that include the extent of disease (stage), the presence of cytogenetic abnormalities, a patient’s baseline organ function and fitness, and the patient’s response to treatment. Thus, stage alone does not determine the treatment plan.

For decades, an older myeloma staging system called the “Durie-Salmon Staging System” has been used. The Durie-Salmon system evaluates the following factors:

- The patient’s hemoglobin concentration
- The level of blood calcium and the presence of bone lesions detected with imaging studies to determine the extent of the myeloma
- The amount of the monoclonal protein (M protein) in the blood and urine
- The level of kidney function

The newer International Staging System (ISS) for multiple myeloma uses the degree of increase in beta 2 ( $\beta_2$ )-microglobulin, as well as the degree of decrease in the serum albumin level to determine prognosis at the time of diagnosis. The ISS was revised (R-ISS) in 2015 to include an elevated lactate dehydrogenase (LDH) level or the presence of high-risk cytogenetic abnormalities to make this prognostic index. These measurements allow the doctor to classify the patient’s myeloma as stage I, stage II or stage III (see **Table 3** on page 16).

**Table 3. Myeloma Staging Systems**

Stage	Durie-Salmon Staging System	Revised International Staging System (R-ISS)	Survival for R-ISS
<b>I</b>	<p><b>All of the following:</b></p> <ul style="list-style-type: none"> <li>○ Hemoglobin concentration &gt;10 g/dL</li> <li>○ Serum calcium value normal or ≤12 mg/dL</li> <li>○ X-ray studies of bone showing normal bone structure (scale 0) or solitary bone plasmacytoma only</li> <li>○ Low M-component production rate IgG value &lt;5 g/dL IgA value &lt;3 g/dL</li> <li>○ Urine light chains &lt;4 g/24 hours</li> </ul>	<ul style="list-style-type: none"> <li>○ Serum albumin &gt;3.5 g/dL</li> <li>○ Serum beta 2 (β<sub>2</sub>)-microglobulin &lt;3.5 mg/L</li> <li>○ No high-risk cytogenetic features</li> <li>○ Normal serum lactate dehydrogenase level</li> </ul>	82%
<b>II</b>	<p><b>Neither stage I nor stage III</b></p> <ul style="list-style-type: none"> <li>○ A – No renal failure (creatinine ≤2 mg/dL)</li> <li>○ B – Renal failure (creatinine &gt;2 mg/dL)</li> </ul>	<b>Neither stage I nor stage III</b>	62%
<b>III</b>	<p><b>One or more of the following:</b></p> <ul style="list-style-type: none"> <li>○ Hemoglobin concentration &lt;8.5 g/dL</li> <li>○ Serum calcium value &gt;12 mg/dL</li> <li>○ X-ray studies of bone showing &gt;3 lytic bone lesions</li> <li>○ High M-component production rate IgG value &gt;7 g/dL IgA value &gt;5 g/dL</li> <li>○ Urine light chains &gt;12 g/24 hours</li> </ul>	<p><b>Both of the following:</b></p> <ul style="list-style-type: none"> <li>○ Serum beta 2 (β<sub>2</sub>)-microglobulin &gt;5.5 mg/L</li> <li>○ AND one of the following                             <ul style="list-style-type: none"> <li>○ High-risk cytogenetics t(4;14) t(14;16) del(17p)</li> <li>○ Elevated serum lactate dehydrogenase level</li> </ul> </li> </ul>	40%

**Key:** del, deletion; dL, deciliter; g, gram; Ig, immunoglobulin; L, liter; M-component, monoclonal component; M protein, monoclonal (myeloma) protein; mg, milligram; t, a translocation between chromosomes.

**Sources:** Rajkumar SV. Multiple myeloma: 2022 update on diagnosis, risk stratification, and management. *American Journal of Hematology*.

Shah, D. Multiple Myeloma Workup. Medscape reference.

Palumbo A, Avete-Loiseau H, Olivia S, et al. Revised international staging system for multiple myeloma: a report from international myeloma working group. *American Society of Clinical Oncology*. See References on page 71.

# Treatment Options

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

The goals of treatment for myeloma patients are to reduce symptoms, slow disease progression, achieve long remissions and lengthen survival while preserving quality of life. The goals of research for myeloma treatment include developing curative therapies and improving quality of life during treatment. Speak to your healthcare team about clinical trials as one of your treatment options. See *Clinical Trials for Blood Cancers* on page 39.

**Getting a Second Opinion.** If you have been diagnosed with myeloma, you may want to consult one or more myeloma specialists before proceeding with a treatment plan, to make sure that you receive the therapy that is right for you. Many health insurance companies will authorize a second opinion. When you go to the appointment for a second opinion, make sure that all your medical records are available for examination (including laboratory and imaging test results and bone marrow aspiration and biopsy findings). Upon review of your medical records, the specialist you see for a second opinion can confirm a proposed treatment plan and/or suggest modifications, as well as potentially offer a clinical trial that may only be available at certain institutions. This review will also reassure you that you have explored all of your options.

**Smoldering Myeloma.** Some patients have minimal extent of disease and little evidence of disease progression at the time of diagnosis. This is referred to as “asymptomatic” or “smoldering” myeloma. For patients without signs and/or symptoms who have this indolent form of the disease, “watchful waiting” may be an appropriate approach. In the watch-and-wait approach, treatment is delayed until there are signs and/or symptoms of disease progression. Frequent and careful observation by a doctor is required so that effective treatment can be started when the disease starts advancing. Patients with active (symptomatic) myeloma need immediate treatment.

According to current research, the average rate of progression of smoldering myeloma to active multiple myeloma is approximately 10 percent per year over the first 5 years following diagnosis, 3 percent per year over the next 5 years, and 1.5 percent per year thereafter. The rate of progression may be influenced by the underlying cytogenetic features of the disease. Recent research has made it possible to identify individuals with a higher risk of progression to active myeloma. Some of these patients may benefit from early treatment interventions, and clinical trials are available for them. Your doctor can further discuss these options with you.

**The remainder of this section is about treatment for active myeloma.**

**Treatment Planning.** In order to initiate treatment, patients must meet the diagnostic criteria for myeloma as outlined in **Table 1** on page 7. The treatment approach for each patient is customized based on a number of factors, including:

- Whether treatment is required (smoldering versus active myeloma)
- Extent and characteristics of the disease, such as chromosomal abnormalities
- The rate of disease progression
- The patient's age and fitness (note: the patient's overall health is considered in determining ability to tolerate intensive therapy, rather than age alone)
- The presence of other conditions, such as heart or kidney disease, diabetes or neuropathy
- The risk of treatment-related complications
- The availability/suitability of a clinical trial

Patients are advised to consult a doctor who specializes in myeloma treatment and to discuss the most appropriate treatment option for their situation. Most treatment plans include a combination of different therapies.

Myeloma is best managed with a team approach that may include other medical specialists, such as nephrologists, as well as other healthcare professionals, such as social workers. For example, some patients will need supportive (palliative) care to address the signs and/or symptoms of the disease and the side effects of its treatment. More than likely, they will be contending with complications of myeloma, such as anemia, high blood calcium levels, infections and/or bone damage or osteoporosis (see *Complications, Side Effects and Supportive Care* on page 41 for more information). Likewise, receiving a diagnosis of myeloma can be stressful, and some patients may benefit from speaking with a therapist and/or other patients who are in similar situations. Speaking to a dietitian may be helpful for patients so that they know which foods to avoid during treatment. Finally, having the support of family members and/or friends can improve the patient's sense of wellbeing while they are undergoing treatment.

LLS provides resources for patients to speak to other patients in a program called the *Patti Robinson First Connection® Program*. LLS also provides nutrition information. See page 55 for more information about these (and other) available resources.

The following myeloma-specific therapies are used to treat disease progression and bring about remission:

- Combination drug therapy (see **Tables 4, 5 and 6** on pages 20, 22 and 30)
- One of three types of stem cell transplant
  - Autologous
  - Standard allogeneic

- Reduced-intensity allogeneic
- Immune cellular therapy (chimeric antigen receptor [CAR] T-cell therapy)
- Radiation therapy for localized disease (for example, solitary plasmacytoma or spinal cord compression)
- New and emerging drug therapies (as part of clinical trials)

There is no cure for myeloma but new therapies have improved patient quality of life and survival rates. Treatment has significantly progressed over the last decade with the development of novel agents, combinations of different drug therapies and the use of supportive bone strengthening medications such as bisphosphonate drugs, as well as autologous stem cell transplantation.

**Drug Therapy.** The main treatment for active myeloma is systemic drug therapy (meaning the drugs travel through the bloodstream to kill malignant cells). The initial therapy, or “induction therapy,” for myeloma usually includes a combination of targeted agents and/or standard chemotherapy (see **Table 4, Drug Classes and Drug Mechanisms**; on page 20; **Table 5, Some Drugs Used in the Treatment of Myeloma**; on page 22; and **Table 6, Some Drug Combinations Used to Treat Myeloma**, on page 30. In eligible patients this therapy is often followed by stem cell transplantation (see *Autologous Stem Cell Transplantation* on page 31).

Induction therapy, given before the stem cell transplant, or maintenance therapy has several goals:

- Achieving rapid disease control, potentially reversing organ dysfunction
- Inducing high response rates with as few side effects as possible, so that patients can proceed to the next phase of treatment
- Allowing adequate stem cell collection (harvesting) for transplant

For transplant candidates, drug treatment begins with an induction phase consisting of a combination of agents that do not cause marrow damage, for example: **bortezomib (Velcade®)**, **lenalidomide (Revlimid®)** and **dexamethasone** (a combination known as **VRD**); **bortezomib, cyclophosphamide (Cytoxan®)** and **dexamethasone** (a combination known as **VCD** or **CyBORd**); or other combinations, such as the addition of **daratumumab (Darzalex®)** to one of these regimens. Note that long-term treatment with lenalidomide may decrease stem cell production. So, for transplant candidates, stem cell collection is often performed after three to six cycles, once an adequate treatment response has been achieved.

Researchers continue to study the most effective drugs and drug combinations for myeloma treatment, including newly diagnosed, refractory and relapsed cases. **Table 5** (see page 22) includes a summary of drug options for myeloma patients.

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

**Table 4. Drug Classes and Drug Mechanisms**

<b>Alkylating Agents (DNA-Damaging Drugs)</b>	These drugs work by stopping or slowing the growth of cancer cells
<b>Antibody-Drug Conjugates (ADCs)</b>	Antibody-drug conjugates are immunotherapy drugs designed to target specific proteins (antigens) on the surface of cancer cells. Others are coupled with a chemotherapy drug or attached to a radioactive particle, so they are called “antibody-drug conjugates.” They circulate throughout the body until they attach to the target antigen and then deliver the toxic substance to the cancer cell.
<b>Antitumor Antibiotics</b>	Antitumor antibiotics prevent cell division by either binding to DNA to prevent the cells from duplicating or inhibiting RNA synthesis.
<b>Antimetabolites</b>	Antimetabolites mimic the building blocks of DNA or RNA that cancer cells need to survive and grow. When the cancer cell uses an antimetabolite instead of the natural substances, it cannot produce normal DNA or RNA and the cell dies.
<b>Bispecific B-cell Maturation Antigen (BCMA)</b>	Bispecific antibodies are designed to recognize and bind to two different antigens.
<b>Bisphosphonates</b>	These are drugs that fight myeloma-related bone disease.
<b>Chimeric Antigen Receptor (CAR) T-Cell Therapy</b>	This is a type of cellular immunotherapy that consists of modifying a patient’s own immune cells to recognize and attack cancer cells.

**Table 4. Drug Classes and Drug Mechanisms (continued)**

<b>Corticosteroids</b>	Certain hormones (corticosteroids) can kill lymphocytes. They are believed to work by blocking cell metabolism through their effect on specific genes. In high doses, these synthetic hormones—relatives of the natural hormone cortisol—can kill malignant lymphocytes.
<b>Histone Deacetylase (HDAC) Inhibitors</b>	Histone deacetylase inhibitors are substances that cause a chemical change that stops cancer cells from dividing.
<b>Immunomodulatory Drugs (IMiDs)</b>	Immunomodulatory drugs act in multiple ways to kill myeloma cells and affect other cells, including immune system cells and structural cells. These drugs induce a cancer suppressor response directed by the immune system.
<b>Monoclonal Antibodies</b>	Monoclonal antibodies are laboratory-produced proteins that target specific antigens on the cancer cell's surface to interfere with the cell's function and destroy it. Once the antibody finds and attaches to its target, it can “recruit” (harness) other parts of the immune system to destroy cells that contain the antigen. Some monoclonal antibodies work by themselves and are therefore known as “naked antibodies.” Some monoclonal antibodies are combined with a toxin or radioactive substance.
<b>Proteasome Inhibitors (PIs)</b>	These drugs block the function of the proteasome, leading to the accumulation of proteins in the cancer cells and thereby causing their destruction.
<b>Selective Inhibitors of Nuclear Export (SINE)</b>	SINE compounds block the export of tumor suppressor proteins so that they stay in the nucleus and stop tumor growth, leading to cell death.

**Table 5. Some Drugs Used in the Treatment of Myeloma**

For more information, see the package insert and/or the full prescribing information for each medication (available on the internet).

<b>Drug Name</b> <b>Type of Drug</b> <b>Administration</b>	<b>FDA-Approved Indication</b>
<b>Bortezomib (Velcade®)</b> Proteasome Inhibitor Intravenous (IV) or subcutaneous (sub-Q or SC)	<ul style="list-style-type: none"> <li>○ Approved to treat myeloma</li> <li>○ Bortezomib re-treatment may be considered for patients with myeloma who had previously responded to treatment with bortezomib and who have relapsed at least 6 months after completing prior bortezomib treatment.</li> </ul>
<b>Carfilzomib (Kyprolis®)</b> Proteasome Inhibitor Intravenous (IV)	<ul style="list-style-type: none"> <li>○ Approved for the treatment of patients with relapsed or refractory myeloma, who have received one to three prior lines of therapy, in combination with                             <ul style="list-style-type: none"> <li>○ Lenalidomide and dexamethasone; or</li> <li>○ Dexamethasone; or</li> <li>○ Daratumumab (Darzalex®) and dexamethasone</li> <li>○ Daratumumab and hyaluronidase-fihj (Darzalex Faspro<sup>®</sup>) and dexamethasone; or</li> <li>○ Isatuximab-irfc (Sarclisa<sup>®</sup>) and dexamethasone.</li> </ul> </li> <li>○ Approved as a single agent for the treatment of patients with relapsed or refractory myeloma who have received at least one or more prior lines of therapy</li> </ul>
<b>Carmustine (BicNU®)</b> Alkylating Agent Intravenous (IV)	Approved to treat myeloma in combination with prednisone



**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

<p><b>Ciltacabtagene autoleucl (Carvykti™)</b> Chimeric Antigen Receptor (CAR) T-Cell Therapy Intravenous (IV)</p>	<p>Approved for the treatment of adult patients with relapsed or refractory multiple myeloma after four or more prior lines of therapy, including a proteasome inhibitor, an immunomodulatory agent, and an anti-CD38 monoclonal antibody</p>
<p><b>Cyclophosphamide (Cytoxan®)</b> Alkylating Agent Intravenous (IV) Oral</p>	<p>Approved to be used alone or in combination with other medications to treat myeloma</p>
<p><b>Cytarabine (Cytosine arabinoside, Ara-C, Cytosar-U®)</b> Antimetabolite Intravenous (IV) Subcutaneous (sub-Q or SC)</p>	<p>Used to treat myeloma</p>
<p><b>Daratumumab (Darzalex®)</b> Monoclonal Antibody Intravenous (IV)</p>	<p>Approved for adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with lenalidomide and dexamethasone in newly diagnosed patients who are ineligible for autologous stem cell transplant and in patients with relapsed or refractory myeloma who have received at least one prior line of therapy</li> <li>○ In combination with bortezomib, melphalan and prednisone in newly diagnosed patients who are ineligible for autologous stem cell transplant</li> <li>○ In combination with bortezomib, thalidomide, and dexamethasone in newly diagnosed patients who are eligible for autologous stem cell transplant</li> </ul>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

	<ul style="list-style-type: none"> <li>○ In combination with bortezomib and dexamethasone in patients who have received at least one prior line of therapy</li> <li>○ In combination with carfilzomib and dexamethasone in patients who have received one to three prior lines of therapy</li> <li>○ In combination with pomalidomide and dexamethasone in patients who have received at least two prior lines of therapy including lenalidomide and a proteasome inhibitor</li> <li>○ As monotherapy, in patients who have received at least three prior lines of therapy including a proteasome inhibitor (PI) and an immunomodulatory agent or who are double refractory to a PI and an immunomodulatory agent</li> </ul>
<p><b>Daratumumab and hyaluronidase-fihj (Darzalex Faspro®)</b>          Monoclonal Antibody          Subcutaneous (sub-Q or SC)</p>	<p>Approved for adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with bortezomib, melphalan and prednisone in newly diagnosed patients who are ineligible for autologous stem cell transplant</li> <li>○ In combination with lenalidomide and dexamethasone in newly diagnosed patients who are ineligible for autologous stem cell transplant and in patients with relapsed or refractory myeloma who have received at least one prior line of therapy</li> <li>○ In combination with bortezomib, thalidomide, and dexamethasone in newly diagnosed patients who are eligible for autologous stem cell transplant</li> </ul>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

	<ul style="list-style-type: none"> <li>○ In combination with bortezomib and dexamethasone in patients who have received at least one prior line of therapy</li> <li>○ In combination with carfilzomib and dexamethasone in patients with relapsed or refractory multiple myeloma who have received one to three prior lines of therapy</li> <li>○ As monotherapy, in patients who have received at least three prior lines of therapy including a proteasome inhibitor (PI) and an immunomodulatory agent or who are double refractory to a PI and an immunomodulatory agent</li> <li>○ In combination with pomalidomide and dexamethasone in patients who have received at least one prior line of therapy including lenalidomide and a proteasome inhibitor</li> </ul> <p>Daratumumab may interfere with blood typing for up to 6 months after the final dose. It is important to notify the blood banks at their treatment centers if patients have received this medication, in case a blood transfusion is needed.</p>
<p><b>Denosumab (Xgeva®)</b> Bone-Modifying Agent Subcutaneous (sub-Q or SC)</p>	<p>Approved for myeloma patients for the prevention of skeletal-related problems.</p> <p>This RANKL inhibitor corrects the imbalance between bone formation and destruction found in myeloma.</p>
<p><b>Dexamethasone</b> Corticosteroid Oral or Intravenous (IV)</p>	<p>Used to treat myeloma</p>
<p><b>Doxorubicin (Adriamycin®)</b> Antitumor Antibiotic Intravenous (IV)</p>	<p>Used to treat myeloma alone and in combination with other medications.</p>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

<p><b>Elotuzumab (Empliciti®)</b>          Monoclonal Antibody          Intravenous (IV)</p>	<p>Approved for adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with lenalidomide and dexamethasone in patients who have received one to three prior lines of therapy</li> <li>○ In combination with pomalidomide and dexamethasone in patients who have received at least two prior lines of therapy including lenalidomide and a proteasome inhibitor</li> </ul>
<p><b>Idecabtagene vicleuceel (Abecma®)</b>          Chimeric Antigen Receptor (CAR) T-Cell Therapy          Intravenous (IV)</p>	<p>Approved for the treatment of adult patients with relapsed or refractory multiple myeloma after four or more prior lines of therapy, including an immunomodulatory agent, a proteasome inhibitor, and an anti-CD38 monoclonal antibody</p>
<p><b>Isatuximab-irfc (Sarclisa®)</b>          Monoclonal Antibody          Intravenous (IV)</p>	<p>Approved for adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with pomalidomide and dexamethasone, for patients who have received at least two prior lines of therapy including lenalidomide and a proteasome inhibitor</li> <li>○ In combination with carfilzomib and dexamethasone, for patients with relapsed or refractory myeloma who have received one to three prior lines of therapy</li> </ul>
<p><b>Ixazomib (Ninlaro®)</b>          Proteasome Inhibitor          Oral</p>	<p>Approved for use in combination with lenalidomide and dexamethasone for the treatment of myeloma patients who have received at least one prior line of therapy.</p>
<p><b>Lenalidomide (Revlimid®)</b>          Immunomodulatory Drug (IMiD)          Oral</p>	<p>Approved for the treatment of adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with dexamethasone</li> <li>○ To use as maintenance therapy following autologous stem cell transplant</li> </ul>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

<p><b>Liposomal doxorubicin (Doxil®)</b> Antitumor Antibiotic Intravenous (IV)</p>	<p>Approved in combination with bortezomib in myeloma patients who have not previously received bortezomib and have received at least one prior line of therapy. This is a specially formulated version of the chemotherapy agent doxorubicin.</p> <p>A liposomal medication contains the active drug inside small, fat-like particles. This type of preparation is easier for the body to absorb and allows more medication to reach its target.</p> <p>Study findings indicate that this drug combination increases the time to disease progression, compared to that of bortezomib given alone.</p>
<p><b>Melphalan (Alkeran®)</b> Alkylating Agent Intravenous (IV) Oral</p>	<p>Approved to treat myeloma</p>
<p><b>Melphalan hydrochloride (Evomela®)</b> Alkylating Agent Intravenous (IV)</p>	<p>Approved for the treatment of myeloma patients for use as a high-dose conditioning treatment prior to hematopoietic progenitor (stem) cell transplantation</p>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

<p><b>Pamidronate (Aredia®)</b>          Bisphosphonate          Intravenous (IV)</p>	<p>This drug is a potent inhibitor of bone resorption. It blocks osteoclasts (cells involved in bone breakdown) and alleviates the effects of bone disease by decreasing the pain, likelihood of fractures and high blood calcium levels associated with bone destruction. Studies indicate that the inhibition of myeloma cell growth may be a possible secondary effect of bisphosphonates.</p> <p>Side effects of bisphosphonates can include kidney damage and a rare form of damage to the jaw bone called “osteonecrosis” (see <i>Bone Pain</i> on page 42). Bisphosphonate use is not recommended in patients with monoclonal gammopathy of undetermined significance (MGUS) unless osteoporosis is present.</p>
<p><b>Pomalidomide (Pomalyst®)</b>          Immunomodulatory Drug (IMiD)          Oral</p>	<p>Approved for use in combination with dexamethasone for the treatment of adult myeloma patients who have received at least two prior lines of therapy including lenalidomide and a proteasome inhibitor and have demonstrated disease progression either on or within 60 days of completion of the last therapy</p>
<p><b>Prednisone</b>          Corticosteroid          Oral</p>	<p>Used to treat myeloma</p>

**Table 5. Some Drugs Used in the Treatment of Myeloma (continued)**

<p><b>Selinexor (Xpovio®)</b>          Selective Inhibitor of Nuclear Export (SINE)          Oral</p>	<p>Approved for adult myeloma patients:</p> <ul style="list-style-type: none"> <li>○ In combination with bortezomib and dexamethasone for patients who have received at least one prior line of therapy</li> <li>○ In combination with dexamethasone for patients with relapsed or refractory myeloma who have received at least four prior lines of therapy and whose disease is refractory to at least two proteasome inhibitors, at least two immunomodulatory agents, and an anti-CD38 monoclonal antibody</li> </ul>
<p><b>Teclistamab-cqyv (Tecvayli™)</b>          Bispecific B-cell maturation antigen (BCMA)          Subcutaneous (sub-Q or SC)</p>	<p>Approved for adult patients with relapsed or refractory multiple myeloma who have received at least four prior lines of therapy, including a proteasome inhibitor, an immunomodulatory agent, and an anti-CD38 monoclonal antibody.</p>
<p><b>Thalidomide (Thalomid®)</b>          Immunomodulatory Drug (IMiD)          Oral</p>	<p>Approved for newly diagnosed adult myeloma patients for use in combination with dexamethasone</p>
<p><b>Zoledronic acid (Zometa®)</b>          Bisphosphonate          Intravenous (IV)</p>	<p>This drug is a potent inhibitor of bone resorption. It blocks osteoclasts (cells involved in bone breakdown) and alleviates the effects of bone disease by decreasing the pain, likelihood of fractures and high blood calcium levels associated with bone destruction. Studies indicate that the inhibition of myeloma cell growth may be a possible secondary effect of bisphosphonates.</p> <p>Side effects of bisphosphonates can include kidney damage and a rare form of damage to the jaw bone called “osteonecrosis” (see <i>Bone Pain</i> on page 42). Bisphosphonate use is not recommended in patients with monoclonal gammopathy of undetermined significance (MGUS) unless osteoporosis is present.</p>

**Table 6. Some Drug Combinations Used to Treat Myeloma**

- **MP:** melphalan (Alkeran®), prednisone
- **TD:** thalidomide (Thalomid®), dexamethasone
- **RD:** lenalidomide (Revlimid®), dexamethasone
- **Pom/Dex:** pomalidomide (Pomalyst®), dexamethasone
- **VD:** bortezomib (Velcade®), dexamethasone
- **MPT:** melphalan (Alkeran®), prednisone, Thalomid®
- **VMP:** Velcade®, melphalan, prednisone
- **VTD:** Velcade®, Thalomid®, dexamethasone
- **VCD or CyBorD:** Velcade®, cyclophosphamide (Cytoxan®), dexamethasone
- **VRD:** Velcade®, Revlimid®, dexamethasone
- **D-RVD:** Darzalex®, Velcade®, Revlimid®, dexamethasone
- **CCyD:** carfilzomib (Kyprolis®), cyclophosphamide, dexamethasone
- **KRD:** Kyprolis®, Revlimid®, dexamethasone
- Bortezomib and liposomal doxorubicin (Doxil®)
- Carfilzomib, daratumumab, dexamethasone
- Carfilzomib, daratumumab and hyaluronidase-fihj (Darzalex Faspro®), dexamethasone
- Daratumumab (Darzalex®), bortezomib, melphalan, prednisone
- Daratumumab, lenalidomide, dexamethasone
- Daratumumab and hyaluronidase-fihj, pomalidomide, dexamethasone
- Elotuzumab (Empliciti®), lenalidomide, dexamethasone
- Ixazomib (Ninlaro®), lenalidomide, dexamethasone
- Panobinostat (Farydak®), bortezomib, dexamethasone
- Selinexor (Xpovio®), bortezomib, dexamethasone

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



**Oral Drug Adherence.** Many new myeloma drugs are taken orally (by mouth). In this context, the term “adherence” means staying on a set plan or regimen, taking the medication as prescribed—on the right day and at the right time, and reporting side effects to the healthcare team. If patients are not going to an outpatient clinic to receive treatment, it is important to make sure that they continue to take their medications, as prescribed, at home.

Taking a drug by mouth has many benefits, including improved quality of life, convenience and saving time. Unfortunately, poor adherence to a prescribed oral drug regimen can result in the following problems: drug resistance; poor response to therapy; disease progression; more doctor visits, laboratory tests and hospitalizations, and even death.

**For additional information about oral drug adherence, including treatment barriers and solutions and strategies to overcome them, see the free LLS booklets *Oral Treatment Adherence Facts* and *A Medication Resource for Blood Cancer Patients*.**

**Stem Cell Transplantation.** High-dose chemotherapy and stem cell transplantation are important parts of treatment plans for eligible, recently diagnosed patients with active myeloma. One of the following types of transplants may be used:

- Single or tandem (back-to-back) autologous stem cell transplant
- Standard or reduced intensity conditioning allogeneic stem cell transplant

**Autologous Stem Cell Transplantation.** The patient’s own stem cells are collected for this type of stem cell transplant. These collected cells are eventually transfused back into the patient’s bloodstream. If needed, a doctor may use special medications to help mobilize stem cells and move them into the peripheral blood for collection. “Mobilizing” stem cells means stimulating them to move from the marrow into the bloodstream, so that enough cells can be collected for an autologous transplant. The patient is then treated with high doses of chemotherapy, typically **melphalan**.

After chemotherapy, the stem cells are returned to the patient’s bloodstream by intravenous (IV) infusion (similar to a blood transfusion) to facilitate recovery from the effects of the chemotherapy. The goal is to “rescue” the bone marrow from the effects of the high doses of chemotherapy, infusing healthy stem cells in order to restore normal blood cell production. This procedure is associated with good response rates and remains the standard of care after completion of induction therapy, for eligible patients as determined by the transplant team. However, autologous transplant is not appropriate for all patients and is not a cure for myeloma.

Patients should discuss the benefits and risks of any procedure with their doctors. Response to the transplant is measured by the standard tests used to

monitor myeloma treatment, such as blood, urine protein and bone marrow tests and imaging studies. Myeloma patients who have undergone an autologous transplant may require maintenance therapy.

**Tandem Autologous Stem Cell Transplantation.** This term refers to a planned second course of high-dose chemotherapy and stem cell transplant within 6 months of the first course. According to recent studies, this should only be considered as a treatment option in patients who fail to achieve a good response with the first transplant, in select patients with high-risk cytogenetic features, such as deletion 17p (del[17p]), or for patients with plasma cell leukemia.

The National Comprehensive Cancer Network (NCCN) guidelines recommend collecting enough hematopoietic stem cells for at least one transplant in all eligible patients, and for two transplants in the case of younger patients, if tandem transplant or salvage transplant (after relapse) would be considered.

**Standard and Reduced-Intensity Conditioning Allogeneic Stem Cell Transplantation.** These are other types of stem cell transplants that are used to treat certain types of blood cancer. The main difference between an autologous and an allogeneic transplant is that in an allogeneic transplant the stem cells are obtained from a donor whose cells are compatible with those of the patient, usually a brother or sister, or an unrelated donor. The main advantage of this approach includes a phenomenon called “graft-versus-myeloma effect,” in which donor T cells, acquired during the transplant, help to destroy residual myeloma cells. The opposite of this, called “graft-versus-host effect” (in which donor T cells damage the recipient’s body), can also occur and cause potentially serious side effects. Thus, allogeneic transplantation has a limited role in myeloma treatment, and it should only be done in the context of a clinical trial. Allogeneic transplantation is mainly considered to be a therapeutic option for young patients with high-risk disease who have experienced a relapse and are willing to accept the risks associated with this type of transplant, in exchange for a better chance at long-term survival.

In a reduced-intensity allogeneic transplant, patients receive lower doses of chemotherapy drugs and/or radiation before the transplant. This protocol may be safer than a standard allogeneic stem cell transplant, especially for older patients.

Talk to your doctor to find out if a stem cell transplant is a treatment option for you. **See the free LLS booklet *Blood and Marrow Stem Cell Transplantation* for more information.**

**Maintenance Therapy.** This is the continued use of therapy to maintain the response obtained with induction therapy or stem cell transplantation. During maintenance therapy, medications are given at lower doses or with less frequency to keep the successful results of prior treatment going. Lenalidomide (Revlimid®) is the preferred agent for post-transplant maintenance, based on the

results of several clinical trials. It does not produce the neurotoxicity of other immunomodulatory drugs, such as thalidomide. However, lenalidomide appears to increase the risk for developing a secondary cancer during maintenance therapy, especially after transplantation or after therapy with a regimen that contains melphalan. More information is needed about the effects of maintenance therapy on overall survival, as well as second cancer risk.

Maintenance therapy with bortezomib (Velcade®) or ixazomib (Ninlaro®) is recommended for patients with certain cytogenetic abnormalities, including t(4;14), del(17p), t(14;16) and t(14;20). T stands for “translocation” and del stands for “deletion.” See **Table 5**, beginning on page 22, for full Food and Drug Administration (FDA) approval information.

Maintenance therapy is intended to be continued over the long term. If, or when, there are signs and/or symptoms indicating disease progression, you and your doctor will discuss additional treatment. Patients should share their questions or concerns about disease progression and future treatments with their treatment team. Studies remain ongoing to determine the optimal maintenance regimen and duration of maintenance therapy.

### Questions to Ask Your Doctor About Maintenance Therapy:

- Will I need maintenance therapy?
- What is my risk of disease relapse without maintenance therapy?
- How long will this therapy last?
- What are the long-term side effects of maintenance therapy?
- Will my insurance cover this phase of treatment?
- What would happen if maintenance therapy is discontinued?

**Radiation Therapy.** This treatment, which uses high-energy rays (x-rays) to kill cancer cells, is used selectively in myeloma treatment to kill malignant plasma (myeloma) cells. For example, radiation therapy is the main treatment for solitary plasmacytoma and for carefully selected patients whose bone pain does not respond to chemotherapy. Radiation therapy may, however, be impractical if there are widely distributed areas of painful bone involvement in the body.

**Treatment Outcomes.** With the current advances in treatment and supportive care, survival rates for myeloma patients have improved significantly in the last decades. It is not unusual for myeloma patients to live for 10 years or longer after diagnosis. Outcomes are influenced by a series of patient-specific factors, including disease stage, chromosome abnormalities, age and presence of other medical problems. Patients should discuss their own potential outcomes with their doctors.

# Measuring Treatment Response

During myeloma treatment, patients should be monitored for treatment response and for signs and/or symptoms related to the disease or its treatment (see **Table 7** on page 36). Treatment response should be evaluated after one or two cycles of therapy, continuing after every subsequent cycle. Most of the same tests used to diagnose the disease are also used to monitor treatment response. These may include:

- Imaging studies, such as x-ray imaging, positron emission tomography (PET), magnetic resonance imaging (MRI) and whole-body low-dose CT scans. The combined PET-MRI scans can detect residual bone lesions that are still active in the body. Depending on the number and location of the lesions, a targeted therapy, such as focal radiotherapy, may be used as treatment.
- Blood tests to measure blood cell counts, monoclonal protein (M protein), calcium and creatinine levels, and levels of free light chains
- Urine tests, such as a 24-hour urine protein test to check for the presence of M protein, or a free light chains test for patients with non-secretory myeloma
- Bone marrow aspiration and biopsy

Treatment response, as determined by these well-established methods, is often supplemented with measurements of minimal residual disease (MRD). This term refers to the lowest detectable level of myeloma cells that are still present in the body, either during or after treatment.

Several techniques can be used to detect MRD, including:

- Immunophenotyping of a bone marrow aspirate by flow cytometry. This technique uses antibodies to look for specific proteins on the surface of cells that are unique to each cell type, allowing for identification or “fingerprinting” of those cells. For example, it can help in determining whether plasma cells in the marrow are normal or malignant. This technique uses methods that are widely available and does not require comparison to a previous sample, so it is particularly useful but not standardized by a common technique.
- Polymerase chain reaction using allele-specific oligonucleotide probes (referred to as ASO-PCR), usually performed on a bone marrow sample. This technique is used to expand trace amounts of DNA or RNA, so that the specific type of the DNA or RNA can be determined. It is useful because it allows the hematopathologist to detect a very low level of residual myeloma cells, too low to be seen with a microscope. The technique can detect the presence of one malignant cell among 500,000 to 1 million healthy cells. This test is not commonly available in most clinical laboratories, so its use is limited.

- Next-generation sequencing (NGS) of either a bone marrow or blood sample. This highly sensitive technique uses sequences of immunoglobulin heavy chains from B lymphocytes and plasma cells to detect the presence of malignant cells. This test can detect one malignant plasma cell among 1 million bone marrow cells. **clonoSEQ**, a test for MRD in patients with myeloma or acute lymphoblastic leukemia (ALL), is approved by the FDA.

In general, clinical trials have shown that patients with MRD-negative status (no detectable residual disease) have better outcomes than those with MRD-positive status (detectable residual disease), based on an MRD measurement. The International Myeloma Working Group (IMWG) defined the presence of MRD in myeloma as having one malignant cell in at least  $10^5$  (100,000) normal cells in a bone marrow biopsy sample. Other terms that are sometimes used in this context include “MRD-zero” (MRD-negative status based on several consecutive tests), “immunophenotypic complete response” (all of the criteria for complete response are met and plasma cells are normal, per flow cytometry tests), and “molecular complete response” (all of the criteria for complete response are met and there are no detectable signs and/or symptoms of the disease by ASO-PCR and/or NGS). These techniques, not yet in general use, will likely be used more frequently in coming years.

There is ongoing research to develop MRD testing methods using peripheral blood by looking for circulating malignant plasma cells, cell-free DNA or trace quantities of M protein. This would add an advantage to treatment response assessment by making routine testing possible without the need for invasive procedures.

**For more information, see the free LLS booklet *Minimal Residual Disease (MRD)*.**

**Table 7. Some Terms Used to Describe Myeloma Treatment Responses**

- **Remission**
  - No detectable disease
  - The terms “complete remission” and “partial remission” (or “complete response” and “partial response”) are sometimes used.
- **Stringent complete response**
  - No detectable disease based on serum or urine immunofixation
  - Normal kappa (k) lambda (λ) light chain reaction
  - No detectable disease based on bone marrow flow cytometry
- **Complete response**
  - No sign of monoclonal protein (M protein) using standard tests
  - Disappearance of any soft tissue plasmacytomas
  - Less than 5% plasma cells in bone marrow aspirates
- **Very good partial response**
  - A 90% or greater decrease in M protein level in the blood
  - Urine monoclonal (M) protein level <100 mg in 24-hour urine collection
- **Partial response**
  - A 50% or greater decrease of M protein level in the blood
  - A 90% reduction in M protein level or <200 mg in 24-hour urine collection
  - A 50% or greater reduction in the size of soft tissue plasmacytoma (if present at diagnosis)
- **Minimal response**
  - A reduction between 25% and 50% in M protein level in the blood
  - A reduction between 50% and 89% in M protein level in 24-hour urine collection
  - A 50% or greater reduction in the size of soft tissue plasmacytoma (if present at diagnosis)
- **Stable disease**
  - Not meeting criteria for a complete remission, very good partial response, partial response, minimal response or progressive disease
- **Progressive disease**
  - At least a 25% increase in M protein level in the blood and urine
  - Appearance of new bone lesions, or 50% or greater increase in the size of previous lesions
  - If associated with symptoms, such as a new lytic bone lesion, usually indicates the need to start therapy or to change therapies if the patient is already receiving treatment
  - A biochemical relapse indicates that a patient has signs of relapse on blood and/or urine, but without evidence of worsening organ function

# Treatment Options for Relapsed and Refractory Disease

Almost all myeloma patients will experience relapse (the disease returns after a remission), and/or the disease will become refractory (meaning it does not respond to treatment). The choice of a treatment regimen after relapse is dependent on a series of patient, disease and treatment-related factors, including:

- Previous therapy. If a previous therapy worked and was well tolerated, it can be considered for use again, along with stem cell transplantation.
- Rate of relapse. Patients with rapidly progressing myeloma should be treated with more aggressive combinations of drugs. In contrast, patients with slowly progressing myeloma may be treated with a milder combination therapy.
- Patient health and comorbidities. These are key factors for choosing a treatment regimen, since most patients with relapsed myeloma are older than 70. The general health of the patient and the presence of other health conditions help to determine the type of therapy and dosage that will be used.
- Genetic abnormalities. There is increasing evidence that, in high-risk patients in particular, the disease may progress if additional cytogenetic abnormalities develop over time. Disease progression will be taken into consideration because the treatment team will have to decide if the prior lines of therapy (to which the patient may have become sensitized) can be reused, or if different and/or more aggressive treatment options need be used.

In some instances, if the patient had a good response to a drug or combination of drugs initially, that treatment option may be repeated. Trying one or more of the other therapies that are typically used in initial treatment is another option. These include the following drug combinations:

- **Bortezomib (Velcade®), lenalidomide (Revlimid®), dexamethasone**
- **Carfilzomib (Kyprolis®), dexamethasone**
- **Carfilzomib, lenalidomide, dexamethasone**
- **Carfilzomib, daratumumab and hyaluronidase-fihj (Darzalex Faspro®), dexamethasone**
- **Daratumumab (Darzalex®), bortezomib, dexamethasone**
- **Daratumumab (Darzalex®), lenalidomide, dexamethasone**
- **Daratumumab and hyaluronidase-fihj (Darzalex Faspro®), pomalidomide, dexamethasone**
- **Elotuzumab (Empliciti®), lenalidomide, dexamethasone**

- **Ixazomib (Ninlaro®), lenalidomide, dexamethasone**
- **Pomalidomide (Pomalyst®), bortezomib, dexamethasone**
- **Pomalidomide, elotuzumab, dexamethasone**
- **Pomalidomide, carfilzomib, dexamethasone**
- **Selinexor (Xpovio®), bortezomib, dexamethasone**
- **Teclistamab-cqyv (Tecvayli™)**

Additional options to consider in patients with multiple relapses and disease that is refractory to conventional regimens include antibody-drug conjugates, chimeric antigen receptor (CAR) T-cell or bispecific antibody therapy. For a full list of treatments and their indications for relapsed/refractory myeloma, see **Table 5** starting on page 22.

The use of high-dose chemotherapy followed by autologous stem cell transplantation may also be an option for some patients with relapsed or refractory myeloma—those who have either not been treated with a transplant or who have had a good, durable response to a prior transplant. Allogeneic stem cell transplantation may be considered in young high-risk patients who have a suitable donor.

**Chimeric Antigen Receptor (CAR) T-Cell Therapy.** CAR T-cell therapy is a type of cellular immunotherapy that consists of engineering a patient’s own immune cells to first recognize and then attack cancerous cells. The T cells are genetically engineered to produce receptors on their surface called “chimeric antigen receptors” (CARs). These receptors recognize and bind to a specific target found on the cancerous cells. CAR T-cell immunotherapy for myeloma targets the B-cell maturation antigen (BCMA). BCMA is considered an ideal target because it is expressed on the surface of plasma cells but not on hematopoietic stem cells in the bone marrow.

**Idecabtagene vicleucel (Abecma®)** and **ciltacabtagene autoleucel (Carvykti™)** are FDA approved for the treatment of adult patients with relapsed or refractory multiple myeloma after they have undergone multiple prior lines of therapy. See **Table 5** starting on page 22 for full approval information.

While CAR T-cell therapy can be an effective treatment, it is also associated with a relatively high rate of serious complications. As a result, it can only be given at specialized centers where doctors have expertise in delivering this type of treatment. Some patients may also require therapy to bridge the waiting time (up to 4 to 6 weeks) that it takes to produce the CAR T-cells.

**For more comprehensive information, see the free LLS booklet *Chimeric Antigen Receptor (CAR) T-Cell Therapy*.**



Many new agents being studied in clinical trials are also showing promising results in the treatment of relapsed and refractory cases of myeloma.

## Clinical Trials for Blood Cancers

Every new cancer drug goes through a series of carefully controlled research studies before it can become part of standard cancer care. These research studies are called “clinical trials.” Researchers use them to find better ways to care for and treat people with cancer. In the United States, the FDA requires that all new drugs and other treatments be tested in clinical trials before they can be used. At any given time, there are thousands of cancer clinical trials taking place. Doctors and researchers are always looking for new and better ways to treat cancer. Researchers use cancer clinical trials to study new ways to

- Treat cancer using:
  - A new drug
  - An approved drug to treat a different kind of cancer
  - A new combination of drugs
  - A new way of giving a drug (by mouth, intravenously (IV), etc)
- Management of cancer symptoms and treatment side effects
- Find and diagnose cancer
- Keep cancer from coming back after treatment
- Manage long-term treatment side effects

By taking part in a clinical trial, patients can see doctors who are experts in their disease, gain access to new, cutting-edge therapies, and provide helpful information for future patients. The treatments and information we have today are due in large part to patients who have been willing to join clinical trials. Anyone interested in participating in a clinical trial should talk to their hematologist-oncologist about whether a clinical trial might be right for them. During this conversation it may help to:

- Have a list of questions to ask about the risks and benefits of each trial (visit [www.LLS.org/WhatToAsk](http://www.LLS.org/WhatToAsk) for lists of suggested questions)
- Ask a family member or friend to go with you to your doctor visit—both for support and to take notes

Clinical trials can be difficult to navigate and figure out, but The Leukemia & Lymphoma Society is here to help. Patients and caregivers can work with **Clinical Trial Nurse Navigators** who will help find potential clinical trials, overcome the barriers to enrollment and provide support throughout the entire clinical-trial

process. Our Clinical Trial Nurse Navigators are registered nurses who are experts in blood cancers and clinical trials. Your Clinical Trial Nurse Navigator will:

- Talk with you about your treatment goals
- Help you to understand the clinical-trial process, including your rights as a patient
- Ask you for details about your diagnosis (such as past treatments, treatment responses, and your cancer genetic profile), your current health and your medical history. This information is taken into account and may factor into your eligibility to participate in certain clinical trials
- Help you to understand how your finances, insurance coverage, and support network, as well as your ability and willingness to travel might impact your choice of a clinical trial
- Guide you and help you in your efforts to find and enroll in a clinical trial, including connecting you with trial sites
- Help deal with any problems you might have as you participate in a trial
- Support you throughout the clinical-trial process

**Call an LLS Information Specialist at (800) 955-4572 or visit [www.LLS.org/CTSC](http://www.LLS.org/CTSC) for more information about clinical trials and the Clinical Trial Support Center at LLS.**

**Also, visit [www.LLS.org/booklets](http://www.LLS.org/booklets) to view *Understanding Clinical Trials for Blood Cancers*.**

Contact an LLS Information Specialist at (800) 955-4572 for more information about finding a clinical trial.

**The Promise Study (Research Study on Myeloma).** This study seeks to identify, screen and track individuals who are at high risk of developing myeloma. The goal of the Promise Study is to increase early detection of myeloma precursor conditions in order to develop new therapies that prevent disease progression and improve survival. Study participants are individuals from 45 to 75 years of age who are African American, and/or individuals with a first-degree relative with a plasma cell disorder such as myeloma. All participation is online or by mail. Call, send an email or visit the study's website to learn more.

- Call: (617) 582-8544
- Email: [promisestudy@partners.org](mailto:promisestudy@partners.org)
- Website: [promisestudy.org](http://promisestudy.org)

# Complications, Side Effects and Supportive Care

Supportive (palliative) care for myeloma helps manage the complications of the disease and the adverse side effects of the drugs used for treatment.

**Myelosuppression.** Bone marrow is constantly producing red blood cells, white blood cells and platelets. Interruption or inhibition of this crucial function is called “myelosuppression.” Chemotherapy agents, immunomodulatory drugs such as lenalidomide (Revlimid®) and proteasome inhibitors such as bortezomib (Velcade®) can cause myelosuppression. If not managed effectively, myelosuppression can be life threatening and interfere with treatment planning and quality of life. A reduction in the number of red blood cells can result in anemia, which can make patients feel extremely tired and experience shortness of breath. When there is a decrease in the number of neutrophils, the primary type of white blood cell, a condition called “neutropenia” occurs. Neutropenia can lead to serious infections that require antibiotic therapy and possibly hospitalization. Certain drugs, such as filgrastim (Neupogen®), pegfilgrastim (Neulasta®) or sargramostim (Leukine®), may be prescribed to treat neutropenia. When myelosuppression causes the depletion of the number of platelets in the blood, a condition called “thrombocytopenia” occurs. Patients who have low platelet counts may experience excessive bleeding from cuts or injuries and may need platelet transfusions.

**Infections.** Infections are not just a troublesome medical problem for patients with myeloma; they can also contribute to the risk of dying from the disease. Patients with myeloma may have decreased ability to fight infections effectively because their B lymphocytes do not make antibodies in response to microbes that enter the body. Myeloma can also suppress other parts of the immune system. The effects of chemotherapy or radiation therapy on blood cell production can also decrease the number of white blood cells, which further contributes to the risk of infection. To prevent infections:

- Intravenous immunoglobulin therapy should be considered for patients who experience frequent and life-threatening infections.
- Pneumococcal and influenza vaccination should also be considered. Since multiple myeloma itself is a risk factor for the severity of coronavirus disease 2019 (COVID-19) infection due to its immunosuppressive properties, COVID-19 vaccines are also recommended. Talk to your doctor to get more information.
- Prophylactic treatment against *pneumocystis carinii* pneumonia, herpes and fungal infections is recommended if a high-dose drug regimen has been given.
- Herpes prophylactic treatment should be considered in patients who are receiving proteasome inhibitors or daratumumab (Darzalex®), since these drugs are associated with incidence of herpes zoster.

**Fatigue.** Fatigue is one of the most common complaints reported by myeloma patients. It can be caused by many factors, including disease-related anemia, treatment side effects, physical immobility, sleep disturbances, nutritional deficits, depression, stress and anxiety. Each patient should be evaluated in order to determine if there are other possible causes for the fatigue that are unrelated to myeloma. Management strategies can then be implemented to alleviate the issues causing or related to fatigue.

**Erythropoietin (EPO) Therapy.** In some patients with severe anemia due to the effects of chemotherapy, the administration of an engineered form of the red blood cell growth factor called “erythropoietin” may alleviate the anemia and decrease the need for blood transfusions. However, some studies suggest that treating anemia too aggressively may increase the risk for blood clots. Also, in some forms of cancer, the use of EPO may be associated with a worse outcome, although this may not be the case in myeloma. Patients should discuss the risks and benefits of EPO therapy with their doctors.

**Bone Pain.** This may occur due to bone thinning and lesions caused by the growth of myeloma cells in the bones. Patients may also experience pain that radiates from the back when the vertebrae (back bones) collapse and press on the nerves. Bone fractures may also cause pain. Successful treatment of the disease and its complications may relieve bone pain, but many patients may require medications to relieve the pain, including narcotics. Note: nonsteroidal drugs such as ibuprofen should be avoided in patients with myeloma, given the increased risk of kidney failure. **See the free LLS booklet *Pain Management Facts*.**

Treatment options for bone pain include the following:

- Use of the intravenous bisphosphonates pamidronate (Aredia®) and zoledronic acid (Zometa®) can help to alleviate bone pain and the risk of bone fractures. These drugs also prevent the elevated level of calcium in the blood that results from bone destruction. Because of the increased risk of developing osteonecrosis of the jaw (ONJ) that is associated with bisphosphonates, this treatment should be managed by an experienced oncologist, with close coordination between the oncologist and oral surgeon and/or dental specialist.

Although uncommon, ONJ is a serious condition that has occurred in some patients receiving bisphosphonates. Although no cause-and-effect relationship has been established between bisphosphonate therapy and osteonecrosis, it is suspected. This condition may develop when the jaw fails to heal after a minor procedure, such as a tooth extraction, that results in bone exposure. Symptoms include pain, swelling, poor healing or infection of the gums, loosening of teeth or numbness (or a feeling of heaviness) in the jaw. Some factors that may increase the risk of osteonecrosis are radiation therapy

to the head or neck, chemotherapy, corticosteroid therapy, anemia (a low red blood cell count), infection, poor dental health, alcohol abuse or cigarette smoking, poor nutrition, poor blood circulation or clotting problems.

Before beginning therapy with intravenous (IV) bisphosphonates, it is important to have a dental examination performed by an experienced dentist who has seen and understands ONJ. Dental treatments and procedures that require bone healing should be completed before intravenous bisphosphonate therapy is started. Patients should receive and follow instructions for maintaining good oral hygiene and should have regular dental checkups. For patients who are receiving bisphosphonates and who require dental procedures, there is no evidence to suggest that interrupting bisphosphonate therapy will either prevent or lower the risk of ONJ. Nonetheless, once patients have started bisphosphonate treatment, they should consult with their doctors before undergoing dental procedures. Frequent clinical assessments and conservative (non-invasive) dental management are recommended. Treatment of patients who develop ONJ may include frequent clinical assessments, antibiotics, oral rinses and removable mouth prostheses. Minor dental work may be necessary to remove injured tissue and reduce sharp edges of bone. Typically, surgery is avoided because it may make the ONJ worse, but it is needed and can be helpful in some cases.

- Denosumab (Xgeva®) is a monoclonal antibody approved by the FDA to prevent bone fractures in myeloma patients. Denosumab is administered through subcutaneous injection. This medication is recommended when bisphosphonates cannot be prescribed due to potential damage to the kidneys.
- Vertebroplasty and kyphoplasty are surgical techniques that may be used to help myeloma patients who have back pain. In vertebroplasty, chemical cement is inserted into the damaged or broken vertebrae through a catheter. Kyphoplasty involves inserting and inflating a balloon into the vertebra, to get it into its normal position before stabilizing the area with the chemical cement. These procedures relieve bone compression and may alleviate pain, as well as reduce the amount of pain medication that the patient needs. In some cases, height lost through vertebral collapse is restored. The usefulness of either of these procedures in specific cases of back pain is a matter that should be carefully discussed between patients and their doctors. These techniques tend to relieve pain caused by recent fractures more effectively than they do in cases involving older fractures.

**Kidney Impairment.** Myeloma patients may have serious problems with kidney function for two main reasons. One reason is the excretion of large amounts of monoclonal proteins into the urine. This excess protein can damage the kidney filtration apparatus and the channels or tubules that are important in

urine formation. Another reason is that patients with myeloma often have high levels of calcium (hypercalcemia) or uric acid (hyperuricemia) in the blood. When bones are damaged, calcium is released into the blood. A high level of calcium in the blood causes dehydration that can damage the kidneys. Timely, adequate treatment of myeloma can improve kidney function and, in most cases, potentially even return it to normal. When this is not the case, some patients may need dialysis.

In rare cases, a procedure known as “plasmapheresis and exchange” may be helpful in limiting kidney damage. For example, it may be used for patients who have very recent or acute kidney failure due to high levels of antibody proteins in the blood. However, this approach is controversial. It provides temporary removal of proteins from the blood; however, they will accumulate again if the source of the problem (the myeloma) is not eliminated. The most important and successful treatment for kidney failure secondary to myeloma is to treat the myeloma itself without delay. Drinking adequate amounts of water and other healthy fluids can flush the kidneys and help them filter impurities from the blood. To prevent kidney damage, it is essential to avoid use of nonsteroidal anti-inflammatory drugs (NSAIDs), iodinated IV contrast and aminoglycoside antibiotics.

**Peripheral Neuropathy.** This term refers to nerve damage in the peripheral nervous system, which transmits information from the brain and spinal cord to every other part of the body and vice versa. There are several possible causes for this condition. It can be a result of the disease or a side effect of certain anti-cancer drugs, including vincristine, bortezomib (Velcade®), carfilzomib (Kyprolis®), thalidomide (Thalomid®), pomalidomide (Pomalyst®) and, less commonly, lenalidomide (Revlimid®). Other problems that can either cause or contribute to neuropathy include diabetes, nerve compression caused by vertebral fractures and vitamin deficiencies, particularly of folate or vitamin B<sub>12</sub>. Symptoms may include either temporary or ongoing numbness, tingling, burning, coldness or weakness in the arms or legs. Patients who develop neuropathy while receiving chemotherapy should tell their healthcare providers as soon as the symptoms appear. Often, reducing the dosage of the drugs being used, or stopping them altogether, can alleviate these signs and/or symptoms or even allow them to resolve completely.

**Thrombosis and Embolism.** The term “deep vein thrombosis (DVT)” refers to the condition caused by a blood clot that forms in the deep veins of the body, usually in the legs. Patients who receive myeloma treatments that are associated with DVT risk are usually prescribed medication to reduce the likelihood of developing this condition. It is important for patients to discuss DVT risk with their doctors and ask which of the options to reduce this risk is best for them. A DVT can cause blood flow obstruction, pain and swelling.

Pulmonary embolism is a sudden blockage in a lung artery. In most cases, it happens when a blood clot breaks loose, travels through the bloodstream and lodges in the arteries of the lungs. Depending on the size and number of clots that reach the pulmonary arteries, a patient may experience chest pain, shortness of breath and other potentially severe or even life-threatening effects. Thalidomide (Thalomid®) and lenalidomide (Revlimid®) are associated with an increased incidence of DVT and pulmonary embolism when they are used in combination with corticosteroids, such as dexamethasone. The incidence is particularly increased when these drugs are used in combination with liposomal doxorubicin. Some doctors have observed that taking either thalidomide or lenalidomide and dexamethasone in combination with red blood cell growth factors, such as epoetin alpha (Procrit®) or darbepoetin alfa (Aranesp®), further increases a patient's risk for DVT. Other factors that can increase the risk of DVT include the presence of a central line (central venous catheter), decreased mobility, recent surgery, pregnancy, smoking, a prior history of DVT or a family history of blood-clotting problems.

**See the free LLS booklets *Blood Transfusion*, *Cancer-Related Fatigue* and the *Side Effect Management* series for more information about managing side effects.**

**Hyperviscosity Syndrome.** Occasionally, in some myeloma patients, the monoclonal protein level is so high that it makes the blood “viscous” (thick). This condition, called “hyperviscosity syndrome,” interferes with the blood flow and delivery of oxygen to the tissues. The circulation of the oxygen-carrying red blood cells slows down, and the work of the heart is increased by the difficulty of pumping blood throughout the body. This complication can lead to headaches, dizziness, weakness, fatigue, sleepiness, oozing from cuts and other signs and/or symptoms. Hyperviscosity syndrome is considered a medical emergency and requires urgent treatment with plasmapheresis and exchange, a procedure that rapidly reduces the concentration of monoclonal proteins in the blood. Chemotherapy is needed as well, since plasmapheresis does not reduce the number of cells that are producing these abnormal proteins. If the patient does not receive chemotherapy to kill the myeloma cells, they will continue to produce the abnormal proteins that, with time, will accumulate at high levels again.

**Cryoglobulinemia.** In rare instances, monoclonal immunoglobulin (IgM) may congeal in the blood and lead to poor circulation, especially if the body is exposed to cold temperatures. This is seen most commonly in the fingers, ears and nose. This condition is referred to as “cryoglobulinemia” and can cause joint pain, kidney problems, skin lesions and purpura (purplish or red-brown discoloration of the skin).

**Other Cancers.** Myeloma patients have an increased risk of developing other types of cancer, including acute myeloid leukemia and acute lymphoblastic leukemia, especially after treatment with certain cytotoxic drugs. This rare complication occurs in a small number of patients. **See the free LLS booklets *Acute Myeloid Leukemia in Adults* and *Acute Lymphoblastic Leukemia (ALL) in Adults* for more information.**

## Financial Concerns

Myeloma patients are living longer, primarily because of the development of new and effective drugs. It is estimated that the average myeloma patient will live more than 10 years from the time of diagnosis, and perhaps longer. While this progress is exciting, the financial costs associated with new treatments, such as chimeric antigen receptor (CAR) T-cell therapies, can become an obstacle to treatment, leading to financial toxicity. In addition, the three- and four-drug combinations used in myeloma treatment include costly medications that require continuous use. This can result in a financial burden for patients, limited access to medications and lower adherence to treatments.

Patients can speak to their healthcare team if they have any concerns about being able to afford their medications. A member of the team may be able to provide information and suggest resources that can help. Health insurance plans may not cover all the costs of cancer care, but patients can turn to several other resources that can help them to find assistance in paying for prescription drugs. These include resources from organizations, foundations and prescription assistance programs.

In addition, several major pharmaceutical manufacturers provide patient assistance or prescription assistance programs. These companies may be able to help by providing both insured and uninsured patients with either free or reduced-cost medications.

**You can contact an LLS Information Specialist at (800) 955-4572 for information about our *Co-Pay Assistance Program* and other financial assistance programs. For more information and resources to cope with the financial aspects of cancer care, see the free LLS booklet *Cancer and Your Finances*.**



# Follow-up Care

Progress in myeloma treatment during the last decade is extending survival, along with good quality of life. This progress has led to a better understanding of how the genetic characteristics of myeloma influence patient outcomes and to the development of new myeloma drugs. Although myeloma remains incurable, the advent of less toxic, targeted therapies is making it possible to manage myeloma as a chronic disease in most patients. Myeloma survivors are advised to:

- Maintain regular follow-up appointments with their hematologists-oncologists. Their doctors will monitor them for signs of disease relapse and also inquire about any side effects from treatment or the onset of other medical problems.
- Keep a record of their cancer diagnosis, treatment, and follow-up care needs. This is often called a “survivorship care plan.” Myeloma survivors should ask their doctor for a written survivorship care plan. Share this information with any new healthcare providers you see. The survivorship care plan should include the following information:
  - A list of all healthcare providers
  - A diagnosis summary with specifics such as subtype and/or genetic markers
  - A treatment summary with specifics such as the names, dates, and dosages of chemotherapy or other drugs, site of radiation treatment, surgery and/or transplantation information, response to treatment, and side effects
  - Maintenance treatment information, if applicable
  - A list of possible late effects
  - A schedule for ongoing monitoring with recommended tests, frequency and coordinating provider
  - Health and wellness recommendations such as nutrition, exercise or other disease screenings
  - A vaccination history
- Have regular screenings for cancer. Myeloma is associated with an increased risk of developing acute myeloid leukemia, especially after receiving treatment with certain chemotherapy drugs.
- Seek medical and psychosocial support for fatigue, depression and other long-term effects, if needed.
- Follow established guidelines for good health. Some general steps to consider include:
  - Maintaining a healthy weight
  - Quitting smoking

- Eating a healthy diet
- Staying physically active

**For additional survivorship information, visit [www.LLS.org/survivorshipworkbook](http://www.LLS.org/survivorshipworkbook) to view the free LLS booklet *Navigating Life During and After a Blood Cancer Diagnosis*.**

## Related Diseases

**Monoclonal Gammopathy of Undetermined Significance (MGUS).** This condition, also called “benign monoclonal gammopathy,” is associated with monoclonal protein in the blood. It is present in 5 percent of the general population older than 50 years. Patients with MGUS do not usually experience any signs and/or symptoms of the condition and it does not affect their wellbeing. Consequently, over 50 percent of people who are diagnosed with MGUS have had the condition for many years prior to the diagnosis. Usually, MGUS is found as an incidental finding of routine laboratory tests. Almost all myeloma patients have MGUS before the condition progresses to myeloma, but only 20 percent of people diagnosed with MGUS eventually develop myeloma. Its associated risk of progression to myeloma is approximately 1 percent per year. Patients with MGUS are usually monitored with blood tests once or twice a year to determine if there is any change in the level of monoclonal protein.

**Monoclonal Gammopathy of Renal Significance (MGRS).** This condition occurs when a patient has features of asymptomatic myeloma, but nonetheless requires treatment due to the impact of the monoclonal proteins on kidney function. Both a bone marrow and a kidney biopsy are usually required to make the diagnosis. Typically, treatment for patients with this condition is similar to the treatment for patients with symptomatic myeloma.

**Waldenström Macroglobulinemia (WM).** This disease has some features in common with myeloma. It is a malignancy of B lymphocytes that produce a monoclonal immunoglobulin (IgM) that can be measured in the blood. The malignant B lymphocytes replace the normal bone marrow cells and may cause anemia and other blood cell deficiencies by preventing the normal marrow cells from making blood cells efficiently. The IgM produced by the malignant B lymphocyte is a very large type of IgM, referred to as a “macroglobulin” (large globulin). **For more information, see the free LLS booklet *Waldenström Macroglobulinemia*.**

**Primary Amyloidosis.** This is an uncommon disease process associated with the accumulation of “amyloid” in tissues, such as the heart, the gastrointestinal tract, and the nerves or the skin. There are several types of amyloid. One type is associated with a condition known as “amyloid light-chain (AL) amyloidosis,”

which is caused by the deposit of damaged immunoglobulin light chains (see **Figure 2** on page 8). In some patients with myeloma, the light chains made by plasma cells can result in the formation and deposition (buildup) of amyloid. This type of amyloidosis is called “primary amyloidosis.”

In myeloma patients who have primary amyloidosis, involvement of the heart, intestines or nerves can produce dysfunction in those organs, significantly complicating management of the disease. In patients who have primary amyloidosis without myeloma, the number of plasma cells in the marrow may be normal and the bones may not be affected. In these cases, the malignant B lymphocytes producing the light chains that build up in the tissues and form the amyloid are too few to be detected by a bone marrow biopsy. Diagnosis of amyloidosis relies on some of the same tests used to diagnose myeloma. However, occasionally it is necessary to perform biopsies of other sites, such as the abdominal fat pad, gums, colon, heart or kidneys. Staging is determined based on the results of blood tests that indicate heart function, including tests to measure N-terminal pro-brain natriuretic peptide (NT-proBNP) and either the troponin T or troponin I level. Many of the drugs that work against myeloma are also effective against amyloidosis, including corticosteroids, melphalan, bortezomib (Velcade®) and daratumumab (Darzalex®), while lenalidomide (Revlimid®) should be used with caution. The FDA granted accelerated approval to daratumumab and hyaluronidase-fihj (Darzalex Faspro®) in combination with bortezomib, cyclophosphamide and dexamethasone for newly diagnosed light chain (AL) amyloidosis. Autologous stem cell transplantation is the treatment of choice for patients who are good candidates for this procedure.

**Heavy Chain Diseases.** These make up a family of rare, systemic syndromes involving B lymphocytes. They are called “heavy chain diseases” because the protein made by the malignant lymphocytes is an incomplete immunoglobulin (the heavy chain of the immunoglobulin). See **Figure 2** on page 8. A heavy chain disease is similar to myeloma in that it is a malignancy of B lymphocytes that secrete a characteristic immunoglobulin, but its clinical features are quite different. For example, there is no bone disease. Treatment generally involves chemotherapy, corticosteroids and, in some cases, radiation therapy.

**Light Chain Deposition Disease (LCDD).** This is a systemic disorder that involves the immune system. It is caused by an excess buildup of immunoglobulin light chains in the tissues and organs (see **Figure 2** on page 8). Light chains are an important part of the body’s immune system. However, if they become trapped in the tissues of the kidneys, lungs, skin, joints or blood vessels, the light chains can trigger reactions that lead to tissue or organ inflammation and damage. Early signs and symptoms of LCDD may include protein in the urine, high blood pressure, decreased kidney function and nephrotic syndrome (a kidney disorder that causes the body to eliminate too much protein in the urine). Approximately 50 to 60 percent of patients with LCDD have myeloma, and about 17 percent have monoclonal gammopathy of undetermined significance (MGUS).

**Plasma Cell Leukemia (PCL).** This is rare plasma cell disease that may be primary (without known cause) or secondary (evolving from an existing diagnosis of myeloma). Most cases are primary; only about 5 percent of cases are diagnosed in patients who have myeloma. In this disorder, patients have a high level of plasma cells (greater than 20 percent) circulating in the blood, often creating plasmacytomas throughout the body. This disease is treated like myeloma. However, patients frequently require more aggressive therapy because PCL is more aggressive than myeloma.

**POEMS Syndrome.** This is an uncommon marrow disorder related to myeloma. POEMS is an acronym; the letters represent the five most common features of the syndrome:

**P** for peripheral neuropathy

**O** for organ enlargement

**E** for endocrine gland dysfunction

**M** for monoclonal plasma cells and monoclonal immunoglobulin

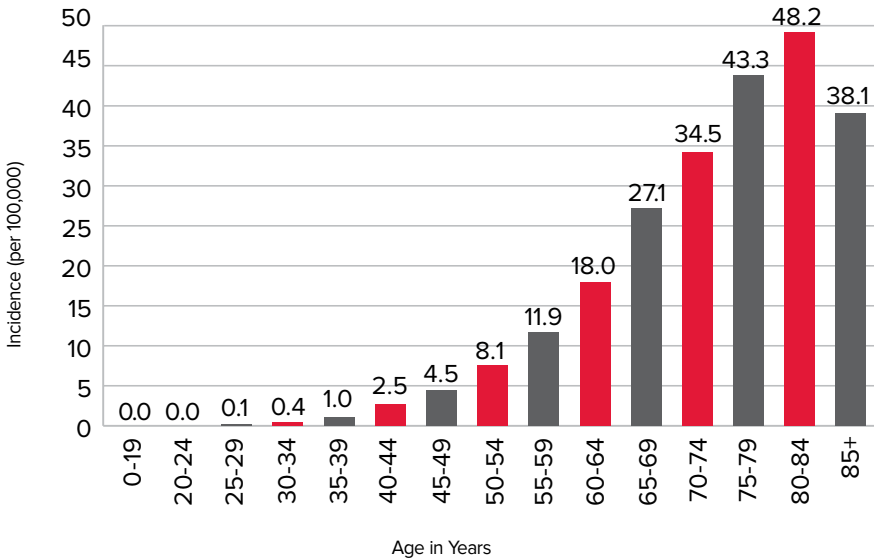
**S** for skin changes

Peripheral neuropathy is often the most disabling feature of the syndrome and can include progressive weakness of the arms or legs. Liver or spleen enlargement is less common. The bone alterations related to the accumulation of plasma cells in the marrow are different from bone alterations in classic myeloma (the marrow looks denser than normal, rather than less dense). Thyroid or sex hormone deficiencies caused by endocrine gland dysfunction may require hormone replacement therapy. Other features not included in the POEMS acronym are high red blood cell or platelet counts, extravascular volume overload (swelling) and lung disease. Patients can benefit from radiation or chemotherapy treatment and, in some cases, from autologous stem cell transplantation.

# Incidence, Causes and Risk Factors

Myeloma is a relatively rare blood disease. Myeloma is seldom diagnosed in people younger than 40 years (see **Figure 3**). The median age at diagnosis is 69 years. Myeloma affects more men than women, and the incidence is more than twice as high in Black individuals as it is in Whites.

**Figure 3. Age-Specific Incidence Rates for Myeloma, 2014-2018**



The horizontal axis shows the age at diagnosis, in 5-year increments, of people in the United States who develop myeloma. The vertical axis represents the number of new cases of myeloma per 100,000 people. Thus, the risk of myeloma is about 10 times greater in those 75 to 79 years old (43.3 cases/100,000 people) compared to those 45 to 49 years old (4.5 cases/100,000 people).

**\* Estimates based on less than 16 cases are suppressed and not shown.**

**Source:** SEER\*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute. [Cited 2021 September 27]. Available from <https://seer.cancer.gov/explorer/>.

**Causes and Risk Factors.** The exact cause of myeloma is not known, but doctors do know that myeloma starts when a change (mutation) occurs in a single B lymphocyte (B cell). Normally, some B lymphocytes develop into plasma cells, which produce the antibodies that help the body fight infection. In myeloma, the B lymphocyte becomes a malignant cell (a myeloma cell) instead of a healthy plasma cell. Researchers are studying the DNA of plasma cells to determine what changes cause healthy plasma cells to become cancer cells. The causes remain unknown, but scientists have found that in almost all people with myeloma, plasma cells have developed genetic abnormalities that likely contributed to the development of cancer in these cells.

Some of the following factors may increase the risk of developing myeloma:

- Age: Most people who develop myeloma are older than 50 years. Fewer cases of myeloma occur in people younger than 40 years.
- Sex: More males than females develop myeloma.
- Race: Blacks have more than twice the age-adjusted incidence rate of myeloma than Whites.
- Medical history: The incidence is higher in people with a history of monoclonal gammopathy of unknown significance (MGUS). For more information about MGUS, see page 48.
- Environmental factors: Some studies are investigating a link between the development of myeloma and exposure to
  - Radiation
  - Certain kinds of chemicals, such as pesticides, fertilizers and Agent Orange
  - Certain metals, such as cadmium, antimony and lead
- Obesity: Research suggests that obese people have a higher incidence of myeloma.
- Presence of chronic immunodeficiency
- Presence of known inflammatory diseases or conditions (for example, cardiovascular disease or type II diabetes)

**Firefighting.** Some studies indicate that firefighters have a statistically significant higher risk for multiple types of cancer than the general population. It is estimated that firefighters are at a 1.53 times higher risk of developing myeloma, compared to the risk for members of the general American public.

Two recent studies examined whether exposure to the wreckage of the World Trade Center (WTC) disaster after the 9/11 attacks increased firefighters' risk of developing cancer. One study indicated that the exposure of firefighters involved in the WTC rescue and recovery efforts to chemicals and environmental carcinogens may be linked to the incidence of monoclonal gammopathy of undetermined significance (MGUS) in this population. Monoclonal gammopathy of undetermined significance is considered a precursor to myeloma. The other study estimated that more WTC firefighters will continue to develop certain types of cancer than would be expected if they had not been exposed to the area of the disaster.

**Visit [www.LLS.org/booklets](http://www.LLS.org/booklets) to order the free Firefighters and Cancer Risk awareness postcards. For information on the World Trade Center Health Program, see page 58.**

# Normal Blood and Bone Marrow

**Blood.** Blood is the liquid that flows through a person's arteries and veins. It carries oxygen and nutrients throughout the body. It also carries away waste products. Blood is composed of proteins within a liquid called "plasma," as well as cells such as red blood cells.

**Plasma.** Plasma is largely made up of water, in which many chemicals are dissolved. These chemicals each have a special role. Factors found in plasma include:

- Proteins
  - Albumin, the most common blood protein
  - Blood-clotting proteins (coagulation factors) made by the liver
  - Erythropoietin, a protein made by the kidneys that stimulates red blood cell production
  - Immunoglobulins, proteins that help the body fight infection
- Hormones, such as thyroid hormone and cortisol
- Minerals, such as iron and magnesium
- Vitamins, such as folate (B<sub>9</sub>) and vitamin B<sub>12</sub>
- Electrolytes, such as calcium, potassium and sodium

**Blood Cells.** Blood cells are formed in the bone marrow, a spongy tissue where blood cells grow and develop. Blood cells start as stem cells. The process of stem cells maturing into blood cells is called "hematopoiesis." The blood cells are suspended in the plasma. See **Figure 4** on page 54.

Once the stem cell is created, it will develop into one of the three types of blood cells:

1. Red blood cells (RBCs) are the cells that carry oxygen. These cells:

- Make up a little less than half of the body's total blood volume.
- Are filled with hemoglobin, the protein that picks up oxygen from the lungs and takes it around the body. It binds with carbon dioxide (CO<sub>2</sub>) and removes it from the cells and then brings it back to the lungs. When a person exhales (breathes out), the CO<sub>2</sub> is removed from the lungs.

2. Platelets (the cells that help blood to clot)

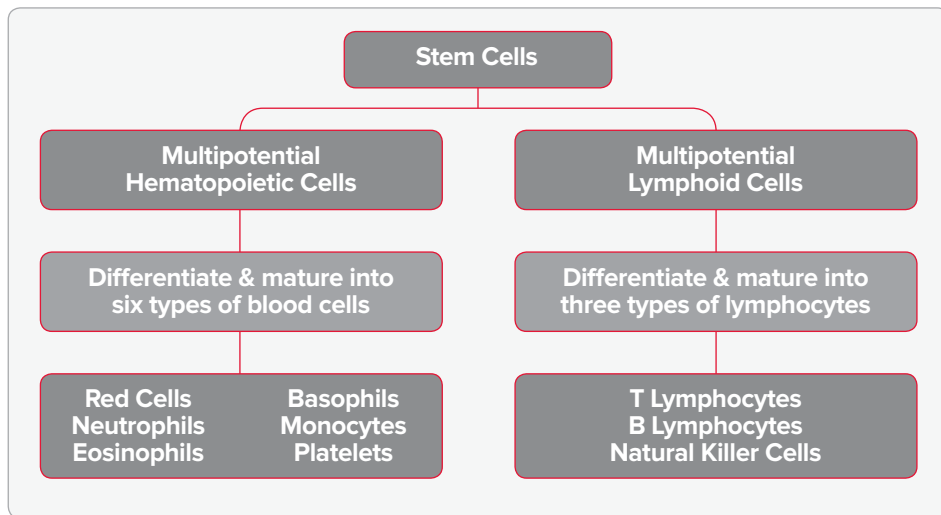
- These are small cells (one-tenth the size of RBCs).
- They help stop bleeding from an injury or cut.
- They stick to the torn surface of the vessel, clump together and plug up

the bleeding site. They form a clot with the help of proteins, such as fibrin, and electrolytes, such as calcium.

3. White blood cells (WBCs) are the cells that fight infections. They include:

- Neutrophils and monocytes. These cells, called “phagocytes,” ingest and destroy bacteria and fungi. Unlike RBCs and platelets, monocytes can leave the bloodstream and enter tissues to attack invading organisms and fight off infection.
- Eosinophils and basophils. These WBCs respond to allergens or parasites.
- Lymphocytes. These WBCs, found mostly in the lymph nodes, spleen and lymphatic channels, are a key part of the immune system. Some enter the bloodstream. There are three major types of lymphocytes:
  - T lymphocytes (T cells)
  - B lymphocytes (B cells)
  - Natural killer cells (NK cells)

**Figure 4. Blood Cell & Lymphocyte Development**



Stem cells develop into blood cells (hematopoiesis) and lymphocytic cells.

**Bone Marrow.** In healthy people, stem cells in the bone marrow produce new blood cells continuously. When blood cells are fully developed, they enter the bloodstream as it passes through the marrow and then circulates throughout the body.

In babies, all bones have active marrow. By the time a person reaches young adulthood, the bones of the hands, feet, arms and legs no longer have blood-forming marrow. In adults, marrow is only found in the spine (vertebrae), hip and shoulder bones, ribs, breastbone and skull.



Hematopoietic stem cells are found in the marrow and have the ability to form the different mature blood cells found in circulation. These stem cells are important because they can be used for transplants. Some stem cells enter the bloodstream and circulate. Doctors know how to stimulate the growth of these cells in the marrow and make them migrate into the bloodstream. Then a special technique called “apheresis” is used to separate them from the circulating blood so they can be collected and stored. Stem cells from the placenta and the umbilical cord of a newborn infant can also be harvested and used for future transplantation.

## Resources and Information

LLS offers free information and services for patients and families affected by blood cancers. This section lists various resources you may find helpful.

### For Help and Information

**Consult with an Information Specialist.** Information Specialists can assist you through cancer treatment, financial and social challenges and give accurate, up-to-date disease, treatment and support information. Our Information Specialists are highly trained oncology social workers and nurses. Language services are available. For more information, please:

- Call: (800) 955-4572 (Monday through Friday, 9 a.m. to 9 p.m. ET)
- Email and Live chat: [www.LLS.org/InformationSpecialists](http://www.LLS.org/InformationSpecialists)

**Clinical Trials (Research Studies).** Research is ongoing to develop new treatment options for patients. LLS offers help for patients and caregivers in understanding, identifying and accessing clinical trials. Pediatric and adult patients and caregivers can work with our Clinical Trial Nurse Navigators who will help find clinical trials and provide personalized support throughout the entire clinical trial process. Visit [www.LLS.org/CTSC](http://www.LLS.org/CTSC) for more information.

**Nutrition Consultations.** Schedule a free one-on-one nutrition consultation with one of our registered dietitians who have expertise in oncology nutrition. Consultations are available to patients and caregivers of all cancer types. Dietitians can assist with information about healthy eating strategies, side effect management and more. Please visit [www.LLS.org/nutrition](http://www.LLS.org/nutrition) for more information.

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

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

**Financial Assistance.** LLS offers financial support to eligible individuals with blood cancer for insurance premiums, co-pays, and non-medical expenses like travel, food, utilities, housing, etc. For more information, please:

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

**Podcast.** *The Bloodline with LLS* is here to remind you that after a diagnosis comes hope. Listen in as patients, caregivers, advocates, doctors and other healthcare professionals discuss diagnosis, treatment options, quality-of-life concerns, treatment side effects, doctor-patient communication and other important survivorship topics. Visit [www.LLS.org/TheBloodline](http://www.LLS.org/TheBloodline) for more information and to subscribe to access exclusive content, submit ideas and topics, and connect with other listeners.

**3D Models.** LLS offers interactive 3D images to help visualize and better understand blood cell development, intrathecal therapy, leukemia, lymphoma, myeloma, MDS, MPNs and lab and imaging tests. Visit [www.LLS.org/3D](http://www.LLS.org/3D) for more.

### **Free Mobile Apps.**

- LLS Coloring For Kids™ — Allows children (and adults) to express their creativity and offers activities to help them learn about blood cancer and its treatment. Visit [www.LLS.org/ColoringApp](http://www.LLS.org/ColoringApp) to download for free.
- LLS Health Manager™ — Helps you track side effects, medication, food and hydration, questions for your doctor, and more. Visit [www.LLS.org/HealthManager](http://www.LLS.org/HealthManager) to download for free.

**Suggested Reading.** LLS provides a list of selected books recommended for patients, caregivers, children and teens. Visit [www.LLS.org/SuggestedReading](http://www.LLS.org/SuggestedReading) to find out more.

### **Connecting with Patients, Caregivers and Community Resources**

**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. Visit [www.LLS.org/community](http://www.LLS.org/community) to join.

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

**Local Programs.** 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), local support groups and other great resources. For more information about these programs or to contact your region, please:

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

**Advocacy and Public Policy.** Working closely with dedicated volunteer advocates, LLS's Office of Public Policy elevates the voices of patients to state and federal elected officials, the White House, governors and even courts. Together, we advocate for safe and effective treatments. We pursue policies that would make care more accessible to all patients. And, most of all, we advocate for the hope for a cure. Want to join our work? Visit [www.LLS.org/advocacy](http://www.LLS.org/advocacy) for more information.

**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) to view the directory.

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

**Información en Español (LLS information in Spanish).** Please visit [www.LLS.org/espanol](http://www.LLS.org/espanol) for more information.

**Language Services.** Let members of your healthcare team know if you need translation or interpreting services because English is not your native language, or if you need other assistance, 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 VA (800) 749-8387
- Visit: [www.publichealth.va.gov/exposures/AgentOrange](http://www.publichealth.va.gov/exposures/AgentOrange)

**Information for Firefighters.** Firefighters are at an increased risk of developing cancer. There are steps that firefighters can take to reduce the risk. Please visit [www.LLS.org/FireFighters](http://www.LLS.org/FireFighters) for resources and information.

**World Trade Center Health Program.** People involved in the aftermath of the 9/11 attacks and subsequently diagnosed with a blood cancer may be able to get 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 and those who lived, worked or were in school in that 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: The National Institute of Mental Health (NIMH) at (866) 615-6464
- Visit: NIMH at [www.nimh.nih.gov](http://www.nimh.nih.gov) and enter “depression” in the search box

## Health Terms

**Albumin.** A major protein in the blood that plays a role in fighting infections and building or repairing muscle tissue. The normal reference range for albumin is 3.5 to 5.5 g/dL (grams per deciliter). The optimal level is 4 g/dL. Test results can vary slightly between laboratories and may be affected by the method the laboratory uses to process the blood sample.

**Allele-Specific Oligonucleotide Polymerase Chain Reaction (ASO-PCR).** An approach to measure patient-specific (allele-specific) minimal residual disease (MRD) levels by PCR, using short stretches of DNA called “oligonucleotides.”

**Allogeneic Stem Cell Transplantation.** A treatment that uses stem cells from a healthy donor to restore a patient’s marrow and blood cells. First, the patient is given a conditioning therapy to treat the blood cancer (high-dose chemotherapy, either with or without total body radiation). This is done to “turn off” (deactivate) the patient’s immune system so that the donor stem cells will not be rejected. A type of allogeneic transplant called “reduced-intensity conditioning” or “nonmyeloablative” stem cell transplant is under study. It uses lower doses of conditioning therapy and may be safer, especially for older patients. See Reduced-Intensity Stem Cell Transplantation. **For more information, visit see the free LLS booklet *Blood and Marrow Stem Cell Transplantation*.**

**Amyloid.** In myeloma, an abnormal protein made by malignant plasma cells. An amyloid deposit (buildup) develops when parts of the immunoglobulin molecule, referred to as “light chains,” accumulate in tissues. In the type of amyloidosis that occurs in myeloma or closely related diseases, organ failure can occur as a result of amyloid deposits in the heart, gastrointestinal tract, kidneys, nerves and other systems.

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

**Antibodies.** The proteins released by plasma cells (derived from B lymphocytes) that recognize and bind to specific foreign substances called “antigens.” Antibodies coat, mark for destruction or inactivate foreign particles, such as bacteria, viruses and harmful toxins.

**Antigen.** A foreign substance, usually a protein, that stimulates an immune response when it is ingested, inhaled or comes into contact with the skin or mucous membranes. Examples of antigens are bacteria, viruses and allergens. Antigens stimulate plasma cells to produce antibodies.

**Apheresis.** The process of removing components of donated blood and returning the unneeded parts to the donor's bloodstream. The process, also called "hemapheresis," circulates blood from a donor through a specialized machine and then back to the donor through an intravenous (IV) line. Apheresis makes it possible to remove desired components from large volumes of blood. Platelets, red blood cells, white blood cells and plasma can be removed separately. This procedure is also used to remove stem cells from circulating blood. They can be frozen, stored and later used for transplantation (instead of stem cells from bone marrow).

**Autologous Stem Cell Transplantation.** A treatment that uses a patient's own stem cells to delay the progression of certain blood cancers. The autologous transplantation process takes place after the patient achieves a complete response (remission), or a good partial response, to the induction drug therapy. In this treatment: 1) the patient's stem cells are harvested, usually from the blood; 2) the stem cells are frozen for later use, and the patient receives a conditioning drug therapy; and 3) the stem cells are thawed and infused back into the patient through an indwelling catheter (central line). Patients receive supportive (palliative) care to help prevent and/or manage the side effects. Generally, after 10 to 14 days, blood counts begin to normalize and the side effects of the conditioning therapy begin to resolve. **For more information about all types of stem cell transplantation, see the free LLS booklet *Blood and Marrow Stem Cell Transplantation*.**

**Basophil.** A type of white blood cell that participates in certain allergic reactions.

**Bence Jones Protein.** An abnormal protein (light chain), made by malignant plasma (myeloma) cells, that enters the blood and is excreted rapidly in the urine. This protein can cause injury to the kidneys or kidney failure when excreted in large amounts. By contrast, a normal immunoglobulin molecule is too large to pass through the kidneys in large amounts, so it is present in the blood but, usually, not in the urine.

**Beta 2 ( $\beta_2$ )-microglobulin.** A cell protein found in the blood. A high level of  $\beta_2$ -microglobulin molecules may be a sign of faster-growing myeloma. Levels of this protein, together with levels of albumin, are significant when staging myeloma.

**Biomarker.** A biological molecule found in blood, other body fluids, or tissues that is a sign of a normal or abnormal process, or of a condition or disease. A biomarker may be used to see how well the body responds to a treatment for a disease or condition. Also called molecular marker.

**Bisphosphonates.** A class of drugs, including pamidronate and zoledronic acid, that are helpful in preventing or minimizing bone loss. Bisphosphonates help slow bone loss by deactivating osteoclasts (cells that break down bone) so that they cannot dissolve bone. Bone thinning (osteoporosis) and fractures are major problems for patients who have myeloma.

**Bone Marrow.** A spongy tissue in the hollow, central cavity of the bones, where blood cell formation occurs. 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 marrow that produces blood cells; in these bones, the marrow is filled with fat cells. When marrow cells have matured into blood cells, they enter the bloodstream as it passes through the marrow and are carried throughout the body.

**Bone Marrow Aspiration.** A procedure done to obtain a bone marrow sample, usually from the patient's hip bone, so the cells can be examined for abnormalities at a laboratory. After medication is given to numb the skin and the bone underneath, the liquid sample is removed with a special needle inserted through the bone into the marrow. The sample is examined under a microscope and assessed not only for the presence of blood cancer but also the extent of the disease. The cells obtained can also be used for cytogenetic analysis, flow cytometry and other tests.

Bone marrow aspiration and bone marrow biopsy may be done in the doctor's office or in a hospital and are almost always done together. Both tests are also done after treatment to determine the proportion of blood cancer cells that have been killed by therapy.

**Bone Marrow Biopsy.** A procedure done to obtain a bone marrow sample, usually from the hip (pelvic) bone, so the cells can be examined for abnormalities at a laboratory. This test differs from a bone marrow aspiration in that a solid, rather than a liquid sample is taken. After medication is given to numb the skin and bone, a special hollow needle is used to remove a sample of bone containing marrow. The marrow is examined under a microscope to determine if abnormal cells are present.

Bone marrow aspiration and bone marrow biopsy may be done in the doctor's office or in a hospital and are almost always done together. Both tests are also done after treatment to determine the proportion of blood cancer cells that have been killed by therapy.

**Chemotherapy.** The use of chemicals (drugs/medications) to kill malignant cells. Numerous chemicals have been developed for this purpose, and some act by injuring the DNA of the cancer cells. When the DNA is injured, the cells cannot grow or survive. Successful chemotherapy depends on the fact that malignant cells are somewhat more sensitive to the chemicals than normal cells. Bone marrow cells are sensitive to these chemicals, which also cause injury to the gastrointestinal tract, skin and hair follicles, leading to mouth sores and hair loss. These are the most common side effects of chemotherapy. Sometimes clinicians use the term "chemotherapy" to refer to any treatment for cancer, even those that are newer, such as immunotherapies, that may not have the same side effects as conventional chemotherapy.

**Computed Tomography (CT) Scan.** A technique for obtaining images of body tissues and organs, in which x-ray transmissions are converted into detailed images using a computer to synthesize the x-ray data. The images are displayed as a cross section of the body at any level, from the head to the feet. A CT scan of the chest, abdomen or pelvis permits detection of an enlarged lymph node, liver or spleen. A CT scan can be used to measure the size of these and other body structures, as well as of plasmacytomas, before, during and after treatment. This type of scan is sometimes done with an intravenous and/or oral contrast agent. The contrast helps doctors get a more detailed picture of what is going on inside the body, but intravenous contrast agents can, in rare cases, cause some kidney damage.



**Cytogenetic Analysis.** The process of analyzing the number and size of the chromosomes of cells. Chromosome alterations can be detected, and in some cases, it is possible to identify the actual genes that have been affected. These findings are very helpful in diagnosing specific types of blood cancer, determining treatment approaches and monitoring treatment response. The individual who prepares and examines the chromosomes and interprets the results is called a “cytogeneticist.”

**Cytokines.** Cell-derived chemicals that are secreted by various types of cells and act on other cells to stimulate or inhibit their function. (The prefix “cyto” means “cell.”) Chemicals derived from lymphocytes are called “lymphokines.” Chemicals derived from lymphocytes that act on other white blood cells are called “interleukins.”

**Differentiation.** The process by which stem cells develop into functional cells of a single blood cell line. Differentiation of stem cells forms red blood cells, platelets, the different types of white blood cells (neutrophils, monocytes, eosinophils, basophils and lymphocytes), as well as normal plasma cells.

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

**Extramedullary Plasmacytoma.** See Plasmacytoma.

**Fluorescence In Situ Hybridization (FISH).** A technique for studying chromosomes in tissues using DNA probes tagged with fluorescent molecules that emit light of different wavelengths and colors. The probes bind to the chromosomes within the cells, and the chromosomes emit color. This test can help doctors detect specific mutations in the chromosomes, but only those for which probes are used.

**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 production of monocytes.

**Heavy Chains.** Any of the large protein chains of the five classes (IgA, IgD, IgE, IgG and IgM) that, paired with the light chains, make up the antibody molecule of an immunoglobulin. See Immunoglobulin (Ig); Light Chain.

**Hematologist.** A doctor who specializes in the treatment of blood diseases. This specialist is either an internist who treats adults or a pediatrician who treats children.

**Hematopathologist.** See Pathologist.

**Hypercalcemia.** An abnormally high concentration of calcium in the blood. In myeloma, the breakdown of bone, which is rich in calcium, is the main cause of a high level of calcium in the blood and urine. Hypercalcemia can contribute to weakness, loss of appetite, nausea, confusion, constipation, lethargy and other symptoms, as well as to kidney damage.

**Immunoglobulin (Ig).** A protein that helps the body fight infection. Normal plasma cells produce one of five types of antibodies (polyclonal immunoglobulins): IgG, IgA, IgM, IgE or IgD. Low levels of immunoglobulin may be a cause of repeated infections in some patients. Also called “gamma globulin.”

**Immunophenotyping.** Use of flow cytometry to identify each individual type of cell in a sample (for example, cells in a marrow aspirate). This is done using antibodies that recognize different cell surface proteins that are characteristic of each cell type and are therefore different for B cells, T cells and plasma cells, among others, similar to the process of fingerprinting.

**Immunotherapy.** Any of several treatment approaches that harness the body’s immune system to treat diseases. These therapies include monoclonal antibody therapy, radioimmunotherapy and vaccine therapy.

**Light Chain.** Either of the two small protein chains that, when linked to heavy chains, make up the antibody molecule of an immunoglobulin. There are two types of light chains, referred to as kappa (k) and lambda ( $\lambda$ ), and they are unrelated to the immunoglobulin (Ig) classes (IgA, IgD, IgE, IgG and IgM). An example of a light chain is a Bence Jones protein. See Bence Jones Protein; Heavy Chains; Immunoglobulin (Ig).

**Lymphocyte.** A type of white blood cell that is essential to the body’s immune system. There are three major types of lymphocytes: 1) B lymphocytes (B cells), which produce antibodies to help combat infectious agents, such as bacteria, viruses and fungi; 2) T lymphocytes (T cells), which have several functions, including assisting B lymphocytes to make antibodies; and 3) natural killer cells, which can attack virus infected cells or tumor cells.

**Lytic Lesions.** Holes in the bones where the tissue has been destroyed as a result of myeloma. These lesions are visible in x-ray images. Also known as “osteolytic lesions.”

**Magnetic Resonance Imaging (MRI) Scan.** A test that provides detailed images of body structures. It differs from the computed tomography (CT) scan in that the patient is not exposed to x-rays. Signals generated in the tissues, in response to a magnetic field produced by a specialized instrument, are converted by computer into images of body structures. It makes it possible to measure the size, or a change in size, of organs (such as the lymph nodes, liver and spleen) or of tumor masses. An MRI scan is often done with an intravenous contrast agent that, while different than the one used for CT scans, can also cause kidney damage in rare cases. All patients scheduled for a CT or MRI scan should let the radiology technicians know that they have myeloma and drink lots of fluids before the scan (if allowed by the test procedure) and after it is completed.

**Marrow.** See Bone Marrow.

**Minimal Residual Disease (MRD).** A low level of cancer cells still present in the body either during or after treatment. It is detected by techniques that are more sensitive than electrophoresis and immunofixation studies of the blood and/or urine, or bone marrow testing by routine pathology alone. Examples include flow immunophenotyping (cytometry), allele-specific oligonucleotide polymerase chain reaction (ASO-PCR) and next-generation sequencing (NGS).

**Monoclonal Antibody Therapy.** Therapy using proteins (antibodies) made in the laboratory that either react with or attach to antigens on the cancer cells they are targeted against. The antibodies are used therapeutically in three ways: 1) as “naked” antibodies (monoclonal antibodies); 2) as antibodies to which radioactive isotopes are attached (radioimmunotherapies); and 3) as antibodies to which toxins are attached (immunotoxins).

**Monocyte/Macrophage.** A type of white blood cell that makes up about 5 to 10 percent of the cells in normal human blood. The monocyte and the neutrophil are the two major types of cells in the blood that eat and kill microbes. When monocytes leave the blood and enter the tissues, they are converted into 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.

**M Protein.** The simplified term for “monoclonal immunoglobulin,” a type of protein made in large amounts by malignant plasma cells and secreted into the blood. The word “monoclonal” indicates that the protein is derived from a single cell. Normal plasma cells produce many types of proteins (antibodies), called “polyclonal immunoglobulins,” to protect the body against infection caused by invading viruses, bacteria or other agents. The production of M protein does not take place in response to an antigen, such as an infectious agent. M protein can be measured in blood samples, and the amount generally correlates with the extent of the myeloma’s progression. Increases in the amount of the protein in the body usually parallel increasing M protein concentration in the blood, while decreasing M protein concentration in the blood usually reflects regression of the myeloma. In rare cases, myeloma cells stop making M protein, and based on laboratory test results, the condition can appear to be improving while it is actually progressing and the patient usually feels worse. This situation can often be detected through a bone marrow aspiration and biopsy; the findings will usually show increasing numbers of plasma cells. M protein is also referred to as “M component” and “M spike,” in reference to laboratory test results.

**Mutation.** A change in the DNA sequence of a cell. “Germ cell mutations” are mutations present in egg or sperm cells that can be transmitted from parents to their biological children. “Somatic mutations” are mutations that arise in a specific tissue cell after birth and can result in the growth of that cell into a tumor. Most types of cancer arise from a somatic mutation. In leukemia, lymphoma and myeloma, an immature cell undergoes a somatic mutation (or mutations) that leads to the formation of a tumor. If a mutation results from a major abnormality of chromosomes, such as a translocation, it can be detected by cytogenetic analysis. Sometimes the alteration in the gene is more subtle and requires more sensitive tests to identify the original mutated gene (called an “oncogene”).

**Myeloma Cells.** Malignant plasma cells that are the defining characteristic of myeloma. Their appearance may be similar to that of normal plasma cells, but they are present in increased numbers.

**Neutrophil.** The principal phagocyte (microbe-eating cell) in the blood. The neutrophil is the main cell that combats infections. Patients with either certain types of blood cancer or who have undergone chemotherapy often do not have enough neutrophils circulating in their bloodstream. A severe neutrophil deficiency increases the patient’s susceptibility to infections. A neutrophil may be referred to as “poly”

(polymorphonuclear neutrophil) or “seg” (segmented neutrophil) because its nucleus has several lobes.

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

**Nonsecretory Myeloma.** A form of myeloma that occurs in a small percentage of patients, in which abnormal proteins cannot be detected through urine protein electrophoresis (UPEP), serum protein electrophoresis (SPEP) or serum immunofixation electrophoresis (SIFE). However, most of these patients have kappa ( $\kappa$ ) or lambda ( $\lambda$ ) free light chains in the serum, detected through a serum free light chain assay. See Serum Free Light Chain Test; Serum Immunofixation Electrophoresis (SIFE); Serum Protein Electrophoresis (SPEP); Urine Immunofixation Electrophoresis (UIFE); Urine Protein Electrophoresis (UPEP).

**Oligosecretory Myeloma.** A form of myeloma that occurs in a small percentage of patients, in which a low level of abnormal protein is detected.

**Osteoblasts.** Cells that create new bone cells.

**Osteoclasts.** Cells responsible for reabsorbing, or eating up, old bone so it can be reshaped into a stronger and more resilient bone.

**Pathologist.** A doctor who identifies diseases by studying tissues under a microscope. A hematopathologist is a type of pathologist who studies diseases of blood cells by examining blood, bone marrow, lymph node and other tissue samples. In addition to examining samples under a microscope, a hematopathologist also analyzes laboratory, flow cytometry 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 determines the best treatment based on the diagnosis.

**PET Scan.** See Positron Emission Tomography (PET) Scan.

**Plasma.** Liquid that remains when clotting of the blood is prevented.

**Plasma Cell.** A cell derived from the antigen-induced activation and maturation of B lymphocytes; it is the main type of B cell that produces antibodies. Myeloma is a cancer of plasma cells; myeloma cells are malignant plasma cells.

**Plasmacytoma.** A localized tumor of malignant plasma cells, either in a bone or in another tissue of the body. A tumorous area outside of the bones may be referred to as an “extramedullary plasmacytoma.”

**Platelets.** Small cell fragments that stick to the site of a blood vessel injury, aggregate and then seal off the injured blood vessel to stop bleeding. “Thrombocyte” is a synonym for platelet. A part of this word (“thrombo”) is often used as the prefix in terms describing disorders of platelets, such as thrombocytopenia (too few platelets) or thrombocythemia and thrombocytosis (too many platelets).

**Polymerase Chain Reaction (PCR).** A method used to create many copies of a target DNA sequence, which makes it easier to detect when it is at a very low level. This is sometimes done as part of testing to evaluate minimum residual disease (MRD).

**Positron Emission Tomography (PET) Scan.** An imaging test used to detect cancer sites in the body. It uses glucose (a type of sugar), which is marked with a positron particle that emits a radioisotope, such as fluorine 18. Cancer cells utilize more sugar than normal tissues, so the isotope becomes concentrated in areas where cancerous cells are present. To establish the precise location of cancer cells, PET is combined with computed tomography (CT) in a procedure called “PET-CT.” A PET scan can provide complementary information to that obtained by a magnetic resonance imaging (MRI) scan or other radiology tests, but each has its limitations. For example, a very small accumulation of myeloma cells may be undetectable by any one or all of these tests.

**Red Blood Cells.** Blood cells that carry hemoglobin, which binds to oxygen and carries 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. Also called “erythrocytes.”

**Reduced-Intensity Conditioning Stem Cell Transplantation.** A form of allogeneic transplantation now being studied in clinical trials. In reduced-intensity conditioning (also called “nonmyeloablative”) stem cell transplantation, patients receive lower doses of chemotherapy drugs and/or radiation in preparation for the transplant, compared to the doses used for standard allogeneic transplants. 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 (which is called the “graft-versus-tumor effect”), but sometimes the donor cells can also attack and damage host tissues (a complication called

“graft-versus-host disease”). More research is needed to determine the effectiveness of this treatment for myeloma patients. Studies to determine the usefulness of reduced-intensity stem cell transplantation in older patients are also under way. **For more information about all types of stem cell transplantation, see the free LLS booklet *Blood and Marrow Stem Cell Transplantation*.**

**Refractory.** The term used to describe a disease that is either progressing despite ongoing treatment, does not respond at all to treatment, or starts to progress significantly within 60 days of stopping treatment.

**Relapse.** The term used to describe a disease that initially responds to therapy but then begins to progress. Usually, the disease must begin to progress 60 days or more after treatment ends for it to be considered relapsed.

**Remission.** The disappearance of evidence of a disease, usually as a result of treatment. The terms “complete remission” (and “partial remission, sometimes referred to as “partial response”), and “complete response” are used to further classify the remission. See **Table 7** on page 37.

**Serum.** The liquid that remains after the blood has clotted.

**Serum Free Light Chain Test.** A diagnostic test that measures the amount of free light chains (protein components) in blood samples. It is better to perform this test on serum rather than urine samples due to the filtering effects of the kidneys.

**Serum Immunofixation Electrophoresis (SIFE).** A laboratory test that can identify the type of M protein (myeloma protein) being produced by myeloma cells in the blood.

**Serum Protein Electrophoresis (SPEP).** A laboratory test that identifies the presence of abnormal proteins, the absence of normal proteins, and determines increases and decreases of different groups of proteins in serum. This test is typically ordered to detect and identify excessive production of specific proteins (immunoglobulins). All five types of immunoglobulins (IgG, IgA, IgM, IgE, or IgD) are measured by this test. If present, an excessive production of a monoclonal immunoglobulin may be shown on laboratory test results as a spike on a graph (M protein or M spike).

**Skeletal Bone Survey.** Head-to-toe x-ray study of the body undertaken in order to detect the lytic bone lesions, compression fractures and osteoporosis (thinning of the bones) that can result from myeloma.

**Stem Cells.** Immature (undeveloped) cells 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 marrow and circulate in the bloodstream. Using special techniques, stem cells in the blood can be collected, preserved by freezing and later thawed and used for stem cell therapy.

**Stem Cell Transplantation.** See Allogeneic Stem Cell Transplantation; Autologous Stem Cell Transplantation; Reduced-Intensity Conditioning Stem Cell Transplantation.

**Translocation.** A chromosome abnormality in marrow or lymph node cells that occurs when a piece of one chromosome breaks off and attaches to the end of another. In a balanced translocation, genetic material is exchanged between two different chromosomes, with no gain or loss of genetic information. When a translocation takes place, the gene at which the break occurs is often altered. This is one form of somatic mutation that may transform the gene into an oncogene (cancer-causing gene). See Mutation.

**Urine Immunofixation Electrophoresis (UIFE).** A laboratory test that can identify the type of M protein (monoclonal protein) being produced by myeloma cells in the urine.

**Urine Protein Electrophoresis (UPEP).** A laboratory test that uses a 24-hour urine sample to identify the presence of abnormal proteins, to identify the absence of normal proteins, and to determine increases and decreases of different groups of proteins in urine. This test is typically ordered to detect and identify excessive production of specific proteins (immunoglobulins). All five types of immunoglobulins (IgG, IgA, IgM, IgE, or IgD) are measured by this test. If present, an excessive production of a monoclonal immunoglobulin (M protein or M spike) may be shown on laboratory test results as a spike on a graph.

**White Blood Cells.** Any of the five major types of infection-fighting, basically colorless cells in the blood: neutrophils, eosinophils, basophils, monocytes and lymphocytes. Also called “leukocytes.”



# References

Alonso R, Lahuerta JJ. Tumor reduction in multiple myeloma: new concepts for new therapeutics. *Frontiers in Oncology*. 2022;11:800309. doi:10.3389/fonc.2021.800309

American Cancer Society. *Key Statistics About Multiple Myeloma*. <https://www.cancer.org/cancer/multiple-myeloma/about/key-statistics.html> Last revised January 12, 2022. Accessed October 21, 2022.

Ackley J, Ochoa MA, Ghoshal D, et al. Keeping myeloma in check: the past, present and future of immunotherapy in multiple myeloma. *Cancers (Basel)*. 2021;13(19):4787. doi:10.3390/cancers13194787

Bravo-Pérez C, Sola M, Teruel-Montoya R, et al. Minimal residual disease in multiple myeloma: something old, something new. *Cancers (Basel)*. 2021;13(17):4332. doi:10.3390/cancers13174332

Cancer Facts & Figures, 2022. American Cancer Society; 2022.

Charalampous C, Kourelis T. Minimal residual disease assessment in multiple myeloma patients: minimal disease with maximal implications. *Frontiers in Oncology*. 2022;11:801851. doi:10.3389/fonc.2021.801851

Claveau JS, Buadi FK, Kumar S. Current role of allogeneic stem cell transplantation in multiple myeloma. *Oncology and Therapy*. 2022;10(1):105-122. doi:10.1007/s40487-022-00195-3 Epub 2022 April 4.

Dana Farber Cancer Institute. *The Promise Study*. 2022 <https://www.enroll.promisestudy.org/> Accessed October 21, 2022.

Devarakonda S, Jethava Y. Minimal residual disease in multiple myeloma: are we there yet? *International Journal of Hematology and Oncology*. 2020;9(4):IJH29. doi:10.2217/ijh-2020-0018

Gulla A, Anderson KC. Multiple myeloma: the (r)evolution of current therapy and a glance into future. *Haematologica*. 2020;105(10):2358-2367. doi:10.3324/haematol.2020.247015

Guzdar A, Costello C. Supportive care in multiple myeloma. *Current Hematologic Malignancy Reports*. 2020;15(2):56-61. doi:10.1007/s11899-020-00570-9

Hagen P, Zhang J, Barton K. High-risk disease in newly diagnosed multiple myeloma: beyond the R-ISS and IMWG definitions. *Blood Cancer Journal*. 2022;12(5):83. doi:10.1038/s41408-022-00679-5

Hemminki K, Försti A, Houlston R, et al. Epidemiology, genetics and treatment of multiple myeloma and precursor diseases. *International Journal of Cancer*. 2021;149(12):1980-1996. doi:10.1002/ijc.33762 Epub 2021 Aug 30.

International Myeloma Foundation. *Concise Review of the Disease and Treatment Options*. 2018 Edition. <https://www.myeloma.org> Accessed October 21, 2022.

International Myeloma Foundation. *Multiple Myeloma Patient Handbook for the Newly Diagnosed*. 2022 Edition. <https://www.myeloma.org> Accessed October 21, 2022.

Kaplan DA. Multiple Myeloma: Top advances in the past 10 years. *Targeted Therapies in Oncology*. 2022;11(4):70-73

Khazeni S, Bigdeli B. Rapid review on multiple myeloma: current clinical management. *Acta Scientific Pharmaceutical Sciences*. 2022;6(1):134-140.

Landgren O, Zeig-Owens R, Giricz O, et al. Multiple myeloma and its precursor disease among firefighters exposed to the World Trade Center disaster. *JAMA Oncology*. 2018;4(6):821-827. doi:10.1001/jamaoncol.2018.0509

Nalley, C. Multiple myeloma treatment: how far it's come & where it's going. *Oncology Times*. 2019;41(S17):pp 1,2,3,7. doi:10.1097/01.COT.0000581680.26138.04

Memorial Sloan Kettering Cancer Center. *Multiple Myeloma: Improved Prognosis with the Latest Treatments*. June 21, 2022. <https://www.mskcc.org/news/multiple-myeloma-improved-prognosis-latest-treatments> Accessed October 21, 2022.

Nathwani N, Bertamini L, Banerjee R, et al. When and how to treat relapsed multiple myeloma. *American Society of Clinical Oncology Education Booklet*. 2021;41:358-375. doi:10.1200/EDBK\_320129

NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®). Multiple Myeloma. Version 5.2022 – March 9, 2022. [https://www.nccn.org/professionals/physician\\_gls/pdf/myeloma.pdf](https://www.nccn.org/professionals/physician_gls/pdf/myeloma.pdf) Accessed October 21, 2022.

NCCN Guidelines for Patients®. Multiple myeloma, 2022. <https://www.nccn.org/patients/guidelines/content/PDF/myeloma-patient.pdf> Accessed October 21, 2022

PDQ® Adult Treatment Editorial Board. PDQ Plasma Cell Neoplasms (Including Multiple Myeloma) Treatment. Bethesda, MD: National Cancer Institute. Updated 06/03/2022. <https://www.cancer.gov/types/myeloma/patient/myeloma-treatment-pdq>. Accessed October 21, 2022. [PMID: 26389437]

Rajkumar SV. Multiple myeloma: 2022 update on diagnosis, risk stratification, and management. *American Journal of Hematology*. 2022;97(8):1086-1107. doi:10.1002/ajh.26590 Epub 2022 May 23.

SEER\*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute. [Cited 2021 September 27]. Available from <https://seer.cancer.gov/explorer/>.

Shah, D. Multiple Myeloma Workup. Medscape reference. <https://emedicine.medscape.com/article/204369-workup#c19> Updated March 3, 2022. Accessed October 21, 2022

Stalker ME, Mark TM. Clinical Management of Triple-Class Refractory Multiple Myeloma: A Review of Current Strategies and Emerging Therapies. *Current Oncology*. 2022;23;29(7):4464-4477. doi:10.3390/curroncol29070355.

Su CT, Ye JC. Emerging therapies for relapsed/refractory multiple myeloma: CAR-T and beyond. *Journal of Hematology and Oncology*. 2021;14(1):115. doi:10.1186/s13045-021-01109-y

Teoh PJ, Chng WJ. CAR T-cell therapy in multiple myeloma: more room for improvement. *Blood Cancer Journal*. 2021;11(4):84. doi:10.1038/s41408-021-00469-5

US Food and Drug Administration. (2021, July 9). FDA approves daratumumab and hyaluronidase-fihj with pomalidomide and dexamethasone for multiple myeloma [press release]. <https://www.fda.gov/drugs/resources-information-approved-drugs/fda-approves-daratumumab-and-hyaluronidase-fihj-pomalidomide-and-dexamethasone-multiple-myeloma>. Accessed October 21, 2022.

US Food and Drug Administration. (2021, November 30). FDA approves Darzalex Faspro, Kyprolis and Dexamethasone for Multiple Myeloma [press release]. <https://www.fda.gov/drugs/resources-information-approved-drugs/fda-approves-darzalex-faspro-kyprolis-and-dexamethasone-multiple-myeloma>. Accessed October 21, 2022.

US Food and Drug Administration. (2022, February 28). FDA approves ciltacabtagene autoleucel for relapsed or refractory multiple myeloma [press release]. <https://www.fda.gov/drugs/resources-information-approved-drugs/fda-approves-ciltacabtagene-autoleucel-relapsed-or-refractory-multiple-myeloma>. Accessed October 21, 2022.

Vick E. Light-chain deposition disease. Medscape Reference. <https://emedicine.medscape.com/article/202585-overview>. Updated October 26, 2021. Accessed October 21, 2022

Wiedmeier-Nutor JE, Bergsagel PL. Review of multiple myeloma genetics including effects on prognosis, response to treatment, and diagnostic workup. *Life (Basel)*. 2022;12(6):812. doi:10.3390/life12060812

Yan ZL, Wang YW, Chang YJ. Cellular immunotherapies for multiple myeloma: current status, challenges, and future directions. *Oncology and Therapy*. 2022;10(1):85-103. doi:10.1007/s40487-022-00186-4 Epub 2022 February 1.





**Get support.**  
Reach out to our  
**Information Specialists.**



The Leukemia & Lymphoma Society® team consists of highly trained oncology social workers and nurses who are available by phone, email and live chat Monday through Friday, 9 a.m. to 9 p.m. (ET).

- Get one-on-one personalized support and information about blood cancers
- Know the questions to ask your doctor
- Discuss financial resources
- Receive individualized clinical-trials searches
- Get connected to resources

Contact us at  
**800.955.4572**  
or [www.LLS.org/  
InformationSpecialists](http://www.LLS.org/InformationSpecialists)

(Language interpreters  
can be requested.)



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

**National Office** 3 International Drive, Suite 200 Rye Brook, NY 10573

The mission of The Leukemia & Lymphoma Society (LLS) is to cure leukemia, lymphoma, Hodgkin's disease and myeloma, and improve the quality of life of patients and their families. Find out more at [www.LLS.org](http://www.LLS.org).