



MULTIPLE MYELOMA UNDERSTANDING YOUR TEST RESULTS

themmrf.org





ABOUT THE **MMRF**

The Multiple Myeloma Research Foundation® (MMRF®) is the largest nonprofit in the world solely focused on accelerating a cure for each and every multiple myeloma patient. We drive the development and delivery of next-generation therapies, leverage data to identify optimal and more personalized treatment approaches, and empower myeloma patients and the broader community with information and resources to extend their lives.

Central to our mission is our commitment to advancing access for all so that every myeloma patient can benefit from the scientific and clinical advances we pursue. Since our inception, the MMRF has raised over \$600 million for research, opened over 100 clinical trials, and helped bring more than 15 FDA-approved therapies to market, which have tripled the life expectancy of myeloma patients.

To learn more about the MMRF, visit themmrf.org.

To speak to a patient navigator at the Patient Navigation Center, call **1-888-841-6673** or email patientnavigator@themmrf.org.

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INTRODUCTION

As a patient with **multiple myeloma**, you'll undergo many tests throughout your diagnosis and treatment. Having the right tests is important: the results help your doctor confirm a myeloma diagnosis, assess the extent of your disease, and monitor your progress once you start treatment.

This booklet describes these tests and what they mean for you and your care team. Words that may be unfamiliar are **bolded** and defined in the Glossary (page 15).

The information in this booklet is not intended to replace the services or advice of trained health care professionals. Please consult with your care provider regarding specific questions relating to your health, especially questions about myeloma diagnosis or treatment.

WHAT IS THE PURPOSE OF LAB TESTING?

Lab testing helps your care team:

- Diagnose multiple myeloma
- Understand how active the disease is
- Track how well treatment is working over time
- Identify side effects early
- Detect signs that myeloma may be returning

COMMON TESTS USED IN MYELOMA CARE

Testing for multiple myeloma includes a range of blood tests, scans, and **bone marrow** tests.

For an overview of common lab tests used in myeloma, see the ***Learn Your Labs High-Impact Topic*** video.

bit.ly/LearnYourLabs_HIT



BLOOD TESTS

Blood tests can tell the care team a great deal about the status of your myeloma, how well your treatment is working, and whether your treatment is causing side effects.

Blood tests are performed on small blood samples typically taken from a vein in your arm.

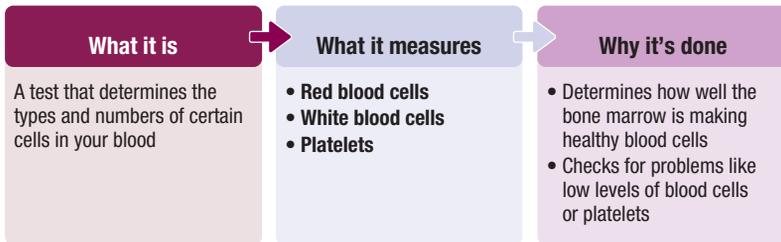
A list of normal ranges for common blood test results is included in the **Appendix** (page 13).

Complete Blood Count

Both myeloma and the drugs used to treat it can affect the number and function of the cells and other components in your blood.

A **complete blood count (CBC)** is a test that can monitor some of these effects of myeloma and its treatments.

Complete blood count.



Low levels of blood cells or platelets can cause complications and can be associated with certain symptoms.

If you notice any of the symptoms below, let your care team know.

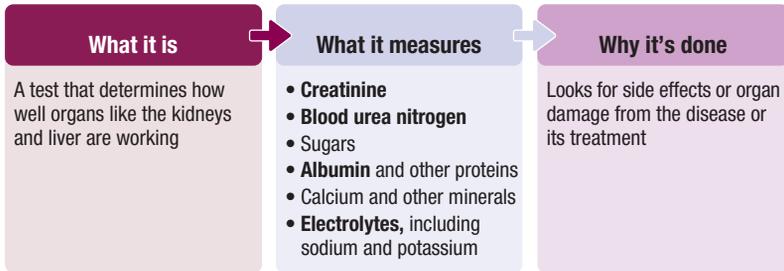
- Tiredness, weakness, shortness of breath, dizziness, or looking pale, which can be signs of low red blood cells (**anemia**)
- Frequent fevers, chills, sore throat, or infections that are hard to shake, which can be signs of low white blood cells (**leukopenia, neutropenia**)
- Easy bruising, nosebleeds, bleeding gums, or tiny red or purple spots on the skin, which can be signs of low platelets (**thrombocytopenia**)

Comprehensive Metabolic Panel

As myeloma cells grow, they can cause changes in the bones, kidneys, and other organs.

A **comprehensive metabolic panel (CMP)** is a test that can help identify these changes by measuring the level of different substances in the blood.

Comprehensive metabolic panel.



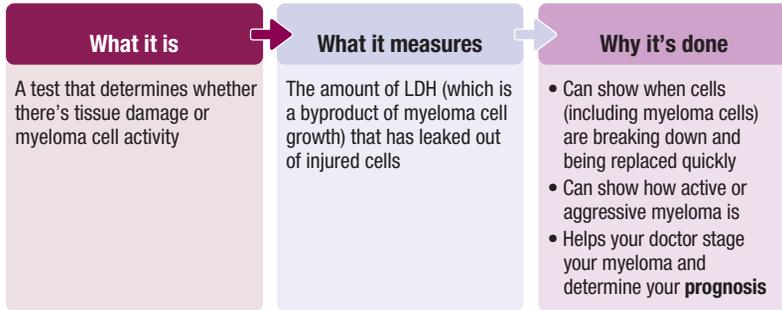
Symptoms that may be linked to changes in CMP results:

- Tiredness, swelling in the legs or feet, nausea, confusion, or less or foamy urine, which can be signs of kidney problems
- Yellowing of the skin or eyes, dark urine, itching, belly pain, or easy bruising, which can be signs of liver problems
- Muscle cramps, irregular heartbeat, extreme thirst, constipation, confusion, or feeling weak or drowsy, which can be signs of abnormal electrolytes or high calcium

Lactate Dehydrogenase

Lactate dehydrogenase (LDH) is an enzyme found in all the cells in your body. When levels of LDH in your blood are high, it could indicate a larger number of myeloma cells or tissue damage from an injury, disease, or infection.

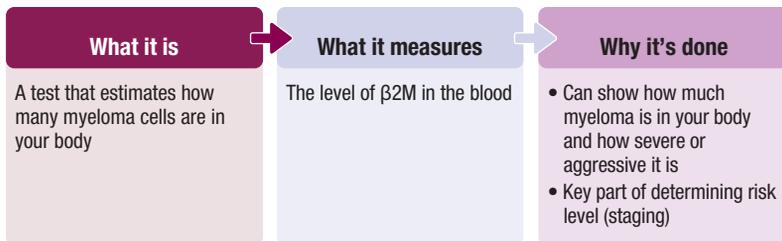
Lactate dehydrogenase.



Beta 2-Microglobulin

Beta-2 microglobulin (β2M) is a protein found on the surface of myeloma cells.

Beta-2 microglobulin.



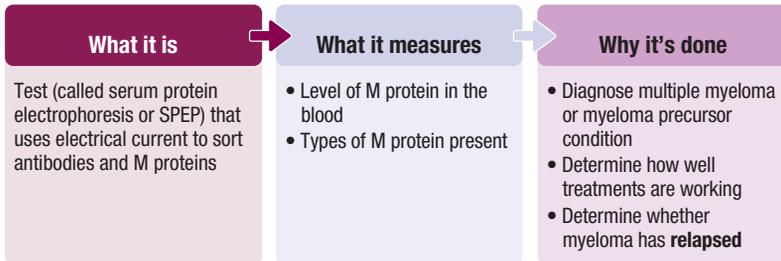
M Protein

Antibodies (also called **immunoglobulins**) are proteins produced by **plasma cells**. They help your body recognize something (like bacteria or viruses) as foreign, and they trigger your **immune system** to eliminate it. There are five different types of antibodies: IgA, IgG, IgM, IgD, and IgE.

M proteins are abnormal non-functional antibodies produced by myeloma cells, which are **malignant** plasma cells. A high level of M protein (referred to as an **M spike**) indicates that you might have multiple myeloma, one of the conditions (**myeloma precursor conditions**) that are known to lead to it, or another blood cancer.

Myeloma cells produce different types of M protein. These proteins can be measured through a technique known as **electrophoresis**.

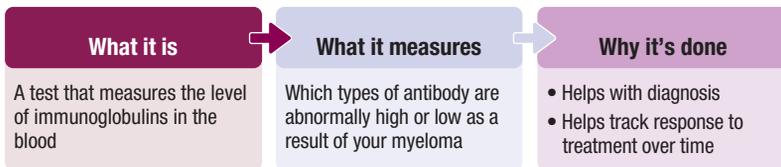
M protein.



Quantitative Immunoglobulins

Measuring the type and levels of immunoglobulins (that is, antibodies) provides further insights into your myeloma.

Quantitative immunoglobulins.

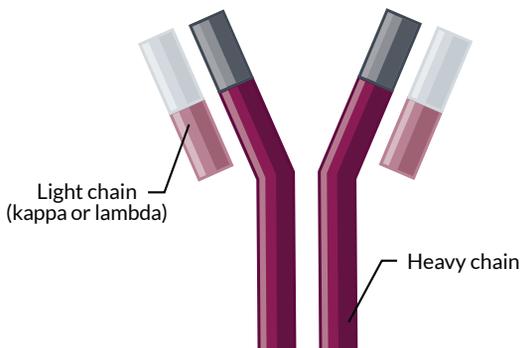


Serum Free Light Chain Assay

Antibodies are formed by two long proteins (heavy chains) and two shorter proteins (**light chains**).

Antibody light chains are classified as either kappa or lambda.

Antibody structure.



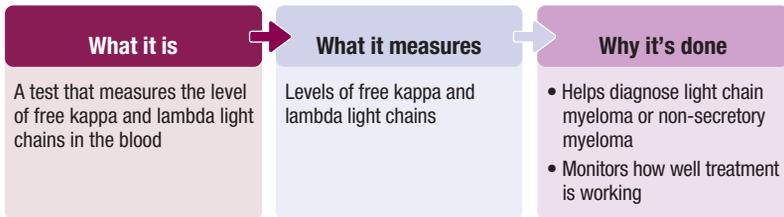
Normally, a person without myeloma has roughly the same number of kappa and lambda light chains, so a serum free light chain assay would show a ratio of one.

Because myeloma cells mainly produce only one type of light chain, a higher level of either kappa or lambda light chains can be a sign that you have myeloma or a related disease such as **light chain myeloma**, a distinct type of myeloma in which myeloma cells produce only light chains instead of whole antibodies.

During myeloma treatment, the level of the light chain made by the myeloma cells decreases, and the ratio of kappa and lambda light chains should return to normal.

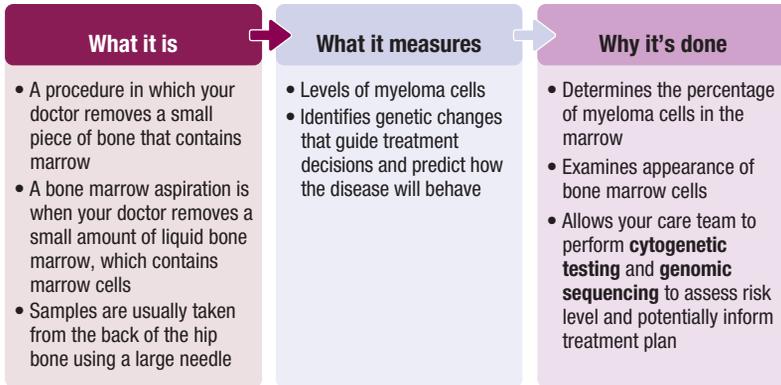
Infrequently, myeloma cells don't produce any kappa or lambda light chains, a condition known as non-secretory myeloma. Patients with **non-secretory myeloma** are monitored using bone marrow biopsies, imaging studies, and blood tests like CBC.

Serum free light chain assay.



Bone marrow tests provide valuable information about the status of your myeloma. Tests conducted on bone marrow help the care team diagnose myeloma and are used to monitor the disease during treatment.

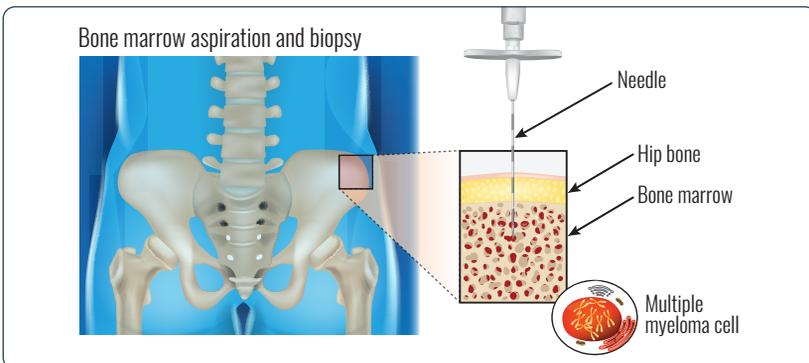
Bone marrow biopsy.



Bone marrow biopsy testing is always done at the time of diagnosis and might be repeated after certain treatments (such as after high-dose chemotherapy and autologous stem cell transplant) or when it's suspected that your myeloma has relapsed.

Pain is typically managed with pre-medication and a local anesthetic prior to this procedure. You may be partially or completely sedated during the procedure. Your care team will let you know in advance how the procedure is conducted at their site.

Bone marrow biopsy.

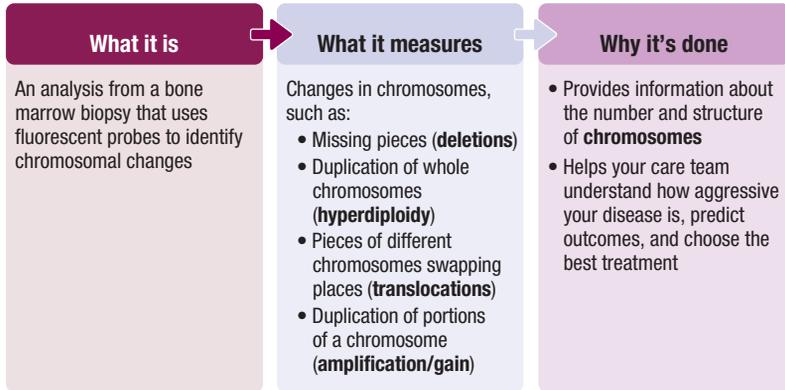


A description of how test results are used to classify response to therapy is included in the **Appendix** (page 13).

Fluorescence in Situ Hybridization

One of the main tests performed on bone marrow samples is **fluorescence in situ hybridization (FISH)**.

FISH testing.



Certain changes in the chromosomes are associated with the development of myeloma, but only a few of these changes are considered high risk and affect your care.

High-risk mutations.

FISH result	What it means
t(4;14)	A translocation between chromosomes 4 and 14
t(14;16)	A translocation between chromosomes 14 and 16
del17p	Deletion of part of chromosome 17
del1p	Deletion of part of chromosome 1
+1q	Extra gene copies (or gain) in part of chromosome 1

For an overview of high-risk disease, see the **High-Risk Disease High-Impact Topic** video.

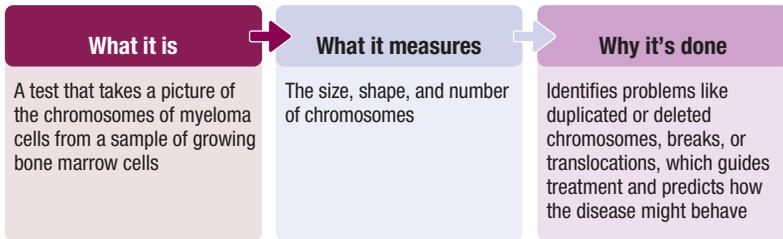
bit.ly/HighRiskDisease_HIT



Karyotyping

Karyotyping is done to view chromosome changes in dividing cancer cells.

Karyotyping.



Some of the information provided by karyotyping overlaps information provided by FISH, like hyperdiploidy, deletions, or translocations.

FISH may be more sensitive in detecting some aberrations but is not as widely available.

Genomic Sequencing

The **DNA** in myeloma cells is made up of the same molecules as the DNA in normal cells. In myeloma cells, however, the DNA sequence has been changed. These changes are called **mutations**.

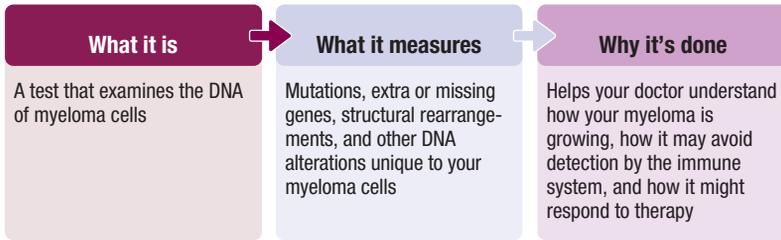
For an overview of how doctors use genomic information, see the **Genomics High-Impact Topic** video.

bit.ly/Genomics_HIT



When mutations develop, the proteins produced by the mutated DNA can no longer do the job they're supposed to do and instead behave abnormally (for example, causing myeloma cells to continue to grow and multiply out of control).

Genomic sequencing.



It's strongly recommended that you undergo genomic sequencing when possible. Ask your doctor if genomic sequencing is available.

Minimal Residual Disease Testing

Using cells taken from a bone marrow biopsy, your doctor may be able to monitor **minimal residual disease (MRD)**.

For an overview of MRD, see the ***Minimal Residual Disease (MRD) High-Impact Topic*** video.

bit.ly/MRD_HIT

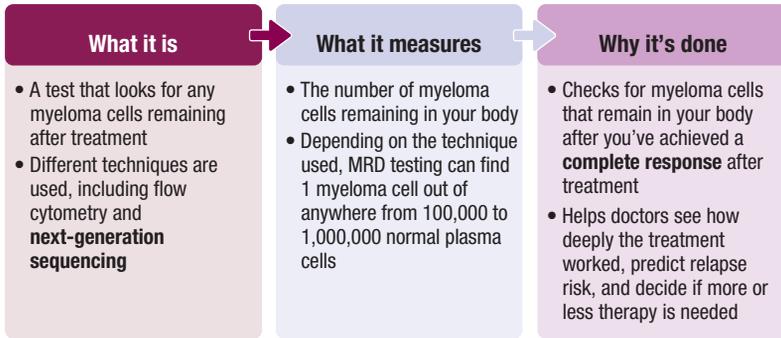


Studies suggest that patients who achieve MRD negativity (that is, myeloma cells are undetectable in the sample) following treatment have a longer time without disease recurrence and may live longer than those who are still MRD positive (myeloma cells detected in the sample).

Not all patients on treatment reach MRD negativity. However, it's possible to go into remission even if you're not MRD-negative.

Although its use is increasing, MRD testing may not be available outside of a clinical trial.

MRD testing.

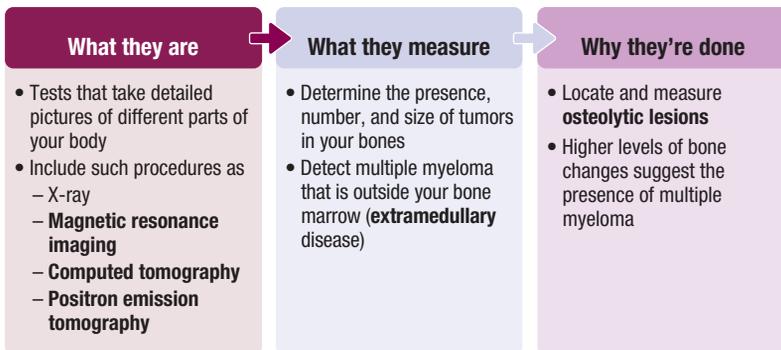


For more information about MRD, refer to the companion booklet *Multiple Myeloma Treatment Overview* and the MMRF website, themmrff.org.

IMAGING STUDIES

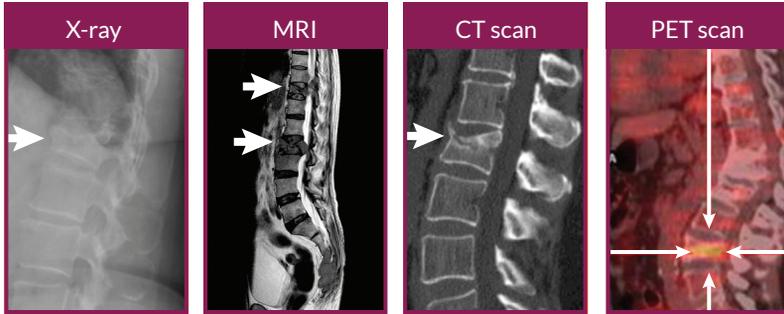
As multiple myeloma gets worse, it can damage your bones. Imaging tests can help detect and monitor this damage.

Imaging studies.



Types of imaging used to detect multiple myeloma.

Assess changes in the bone structure and determine the number and size of tumors in the bone



MRI, magnetic resonance imaging; CT, computed tomography; PET, positron emission tomography
Arrows indicate lytic lesions or bone fractures due to myeloma.

The MMRF would like to thank Joshua Richter, MD, Associate Professor of Medicine, Hematology and Oncology, in the Myeloma Division at the Tisch Cancer Institute at the Icahn School of Medicine at Mount Sinai and the Director of Myeloma at the Blavatnik Family Chelsea Medical Center at Mount Sinai and our patient advocate Kathi H of Helendale, California, for their contributions to this booklet.

APPENDIX

Normal ranges for blood tests.

Test component*	Normal range†
Complete blood count	
Red blood cells	Women: 3.90 to 5.03 × 10 ¹² /L Men: 4.32 to 5.72 × 10 ¹² /L
Hemoglobin	Women: 12.1 to 15.1 g/dL Men: 13.8 to 17.2 g/dL
White blood cells	Total: 3.5 to 10.5 × 10 ⁹ /L Neutrophils (as absolute neutrophil count [ANC]): 1.7 to 7.0 × 10 ⁹ /L Monocytes : 0.2 to 1.0 × 10 ⁹ /L Lymphocytes : 1.0 to 3.0 × 10 ⁹ /L
Platelets	150 to 450 × 10 ⁹ /L
Comprehensive metabolic panel/chemistry profile	
Albumin	3.4 to 5.4 g/dL
BUN (blood urea nitrogen)	6 to 20 mg/dL
Calcium	8.5 to 10.2 mg/dL
Chloride	96 to 106 mEq/L
Creatinine	0.6 to 1.3 mg/dL
Potassium	3.7 to 5.2 mEq/L
Sodium	135 to 145 mEq/L
Lactate dehydrogenase	
LDH	105 IU/L to 333 IU/L
Beta-2 microglobulin	
β2M	0.70 to 1.80 µg/mL
Serum protein electrophoresis	
Albumin	3.8 to 5 g/dL
Alpha-1	0.1 to 0.3 g/dL
Alpha-2	0.6 to 1 g/dL
Beta	0.7 to 1.4 g/dL
Gamma	0.7 to 1.6 g/dL
M protein	0
Quantitative immunoglobulins	
IgA	90 to 386 mg/dL
IgG	603 to 1613 mg/dL
IgM	20 to 172 mg/dL
IgD	0 to 14 mg/dL
IgE	6 to 495 IU/mL
Serum free light chain assay	
Kappa (κ) free light chains	3.3 to 19.4 mg/L
Lambda (λ) free light chains	5.71 to 26.3 mg/L
Ratio of κ/λ	0.26 to 1.65

*Additional components not listed here may be analyzed, but they are not typically used for diagnosing or managing myeloma.

†Normal ranges vary slightly from one institution to another. These ranges may not apply to all patients. Consult your care team to discuss any abnormal lab findings.

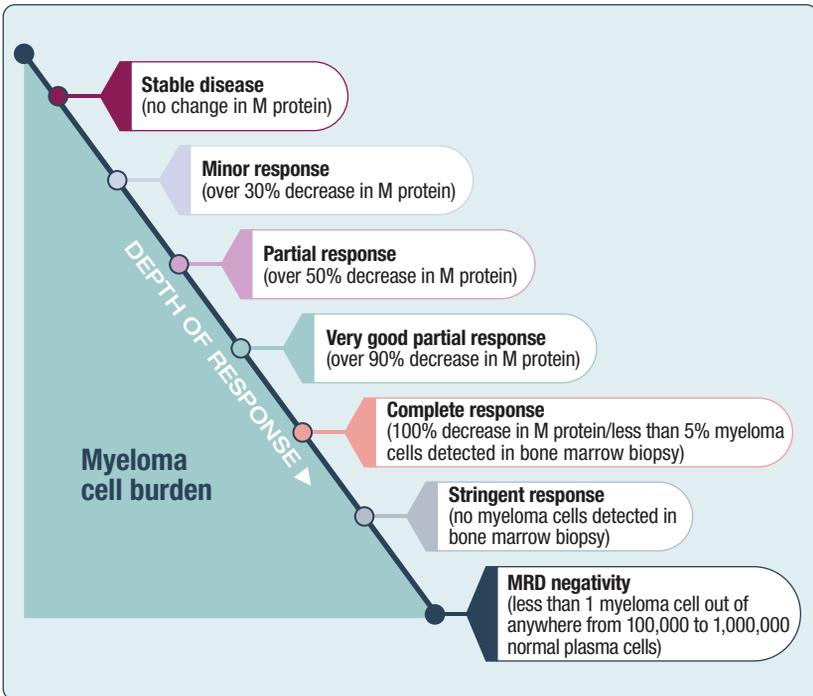
Measuring Response to Therapy

Doctors use lab testing to see how well myeloma treatment is working.

- For newly diagnosed patients, the goal is usually a **very good partial response (VGPR)** or better
- With today's treatments, many patients achieve a complete response

A deeper response means fewer myeloma cells remain in the body. This is usually associated with better prognosis.

Responses to therapy.



GLOSSARY

albumin Protein found in the blood; albumin level can indicate a person's overall health and nutritional status

amplification/gain Chromosomal abnormality in which a section of a chromosome is added to another chromosome

anemia Decrease in the number of red blood cells in the blood

antibodies Proteins produced by plasma cells that help protect the body from infection and disease (also called *immunoglobulins*)

beta-2 microglobulin (β 2M) Protein normally found on the surface of various cells in the body; levels of β 2M in the blood are elevated in inflammatory conditions and in certain blood cell disorders, such as myeloma

blood urea nitrogen (BUN) Byproduct of protein metabolism that is normally filtered out of the blood and found in the urine; elevated levels in the blood can indicate decreased kidney function

bone marrow Soft, spongy tissue found in the center of many bones and the site of blood cell production

bone marrow biopsy Removal of a sample of bone marrow for examination; performed using a needle

chromosome Thread-like structure in a living cell that contains DNA (genetic information)

complete blood count (CBC) Blood test that measures the number of red blood cells, white blood cells, and platelets in the blood and the relative proportions of the various types of white blood cells

complete response Treatment outcome in which the level of plasma cells in the bone marrow is no more than 5%, there is no evidence of myeloma proteins in the serum or urine as measured by standard laboratory techniques, and all signs and symptoms of cancer have disappeared (though cancer still may be in the body)

comprehensive metabolic panel (CMP) Blood test that measures levels of albumin, calcium, blood urea nitrogen (BUN), and creatinine to assess bone status, extent of disease, and kidney and liver function (also known as *chemistry profile*)

computed tomography Imaging technique that uses a computer to generate three-dimensional x-ray pictures

creatinine Product of muscle energy metabolism normally filtered out of the blood; elevated levels indicate decreased kidney function

cytogenetic testing Lab testing that measures the number and structure of chromosomes

deletion Chromosomal abnormality in which a segment of a chromosome is missing

DNA Genetic material of the cell, located in the chromosomes

electrolytes Tiny particles made from minerals like salt, potassium, and calcium that are present in the blood and body fluids and carry a small electrical charge; help the body keep the right amount of water and allow the nerves and muscles (including the heart) to work properly

electrophoresis Lab technique that uses an electrical current to measure protein levels in the blood or urine

extramedullary Located or occurring outside the bone marrow

fluorescence in situ hybridization (FISH) Lab test used to measure if there are extra or missing chromosomes, or if any parts of chromosomes are missing, duplicated, or rearranged

genomic sequencing Study of the DNA of myeloma cells to detect mutations and to see how DNA changes over time

hemoglobin Protein that transports oxygen in the blood

high-risk mutations Changes in myeloma cell DNA that make the disease more aggressive and harder to control

hyperdiploidy Presence of extra copies of one or more chromosomes

immune system Network of cells that protect the body from foreign substances and can destroy infected and cancerous cells

immunoglobulins Proteins that help protect the body from infection (also called *antibodies*)

karyotyping Test that looks at the number and structure of chromosomes

lactate dehydrogenase (LDH) Enzyme found in body tissues; elevated levels in the blood indicate tissue damage and may occur in myeloma

leukopenia Below-normal number of white blood cells

light chains The shorter of two protein chains that make up an antibody, characterized as either kappa or lambda type; when these protein chains are not part of an antibody, they are called *free light chains*

light-chain myeloma Myeloma in which the myeloma cells produce only light chains

lymphocytes Type of white blood cell made up of two main types, B cells and T cells

M proteins Abnormal antibodies produced by myeloma cells that are found in large quantities in the blood and urine of people with myeloma

M spike A sharp increase in the amount of M protein seen on a blood test

magnetic resonance imaging Imaging technique that uses magnetic energy to provide detailed images of bone and soft tissue

malignant Cancerous; able to grow and spread to other parts of the body

minimal residual disease (MRD) Presence of small numbers of myeloma cells in the bone marrow during or after treatment, even when the patient shows no symptoms or signs of disease

monocytes Type of white blood cell that helps the body fight infection

multiple myeloma Blood cancer that develops in the bone marrow as a result of plasma cells transforming into myeloma cells

mutations Defects or errors in a gene

myeloma precursor conditions Any of the preceding phases of active multiple myeloma, called monoclonal gammopathy of undetermined significance or smoldering multiple myeloma, that are characterized by changes in the cells in the bone marrow, but no symptoms or organ damage

neutropenia Below-normal number of *neutrophils*

neutrophils Type of white blood cell that helps the body fight infection

next-generation sequencing Test that uses genomic assessment of bone marrow samples to detect minimal residual disease

non-secretory myeloma Form of myeloma in which myeloma cells do not make or release antibodies

osteolytic lesions Holes in a bone where bone tissue has been destroyed by myeloma cells

plasma cells Antibody-secreting immune cells that develop from B cells; in myeloma, it is these cells that have become cancerous or abnormal

platelets Small cell fragments in the blood that help it to clot

positron emission tomography Imaging technique that uses radioactive glucose to highlight cancer cells

prognosis Prediction of the course and outcome of a disease

red blood cells Blood cells that carry oxygen

relapsed Disease that progresses after initially responding to therapy

thrombocytopenia Decrease in the number of *platelets*

translocation Chromosomal abnormality in which segments of two chromosomes switch positions

very good partial response (VGPR) Treatment outcome in which there is a greater than 90% decrease in M protein

white blood cells One of the major cell types in the blood; attack infection and cancer cells as part of the immune system

NOTES

NOTES



MMRF PATIENT SUPPORT AND RESOURCES

The MMRF supports the myeloma community by providing a broad range of resources for myeloma patients and their family members and caregivers. The MMRF is available to help guide you through your multiple myeloma journey every step of the way.



YOUR QUESTIONS ANSWERED

The Patient Navigation Center is available to answer your questions about disease management and treatments, help you find clinical trials, and connect you with financial and other resources.

Telephone: 1-888-841-6673

Monday–Friday, 9:00 AM to 7:00 PM ET

Email: patientnavigator@themmrf.org

themmrf.org/support/patient-navigation-center

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Connect one-on-one with a trained patient and/or caregiver mentor that can share their patient journeys and experiences.

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FIND A CLINICAL TRIAL

The MMRF Clinical Trial Finder lets you search for a clinical trial in your area.

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ATTEND A MULTIPLE MYELOMA PATIENT SUMMIT

Available in-person and virtually, MMRF Patient Summits discuss new treatments, promising clinical trials, and all the information you need to make well-informed decisions about your treatment and care.

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Technology Industry Professional |
| <input type="checkbox"/> Myeloma Patient Family Member
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