What are aplastic anemia and myelodysplastic syndromes (MDS)?

Aplastic anemia and myelodysplastic syndromes (MDS) are rare and serious disorders that affect the bone marrow and blood. Bone marrow is the soft, spongelike tissue inside the bones. Bone marrow makes stem cells that develop into one of the three types of blood cells—red blood cells, white blood cells, or platelets. Red blood cells contain hemoglobin, an iron-rich protein that gives blood its red color and carries oxygen from the lungs to all parts of the body. White blood cells help the body fight infections. Platelets are blood cell fragments that stick together to seal small cuts or breaks on blood vessel walls and stop bleeding.

In both disorders, bone marrow does not produce enough healthy red or white blood cells or platelets. Too few functioning red and white blood cells can lead to fatigue and infection. Too few platelets can lead to spontaneous or uncontrolled bleeding.

Anemia most often describes a condition in which the number of red blood cells is less than normal, resulting in less oxygen carried to the body's cells. In aplastic anemia, however, normal production of all blood cells slows or stops. Blood cell production declines because bone marrow stem cells are damaged. The number of stem cells also declines because they are unable to replicate themselves. Although production of mature blood cells is seriously impaired in aplastic anemia, the few blood cells that mature and enter the bloodstream are normal.

In MDS, a shortage of bone marrow stem cells usually does not occur, as it does in aplastic anemia. However, the stem cells are defective and do not mature normally. Progenitor cells and immature blood cells are deformed and fail to develop into healthy, mature red or white blood cells or platelets. These cells often die in the bone marrow. Many of the blood cells that do enter the bloodstream do not survive or function normally. Some forms of MDS are prone to develop into leukemia, an aggressive blood cancer.

Blood Cell Production

All three types of blood cells begin as unspecialized stem cells. Stem cells divide and produce more stem cells or can evolve through a series of stages into mature, specialized blood cells of any type. Early in the maturation process, progenitor cells emerge from stem cells. Unlike stem cells, progenitor cells are committed to develop into only one blood cell type and evolve into mature red or white blood cells or platelets.
Who has aplastic anemia and MDS?

Young adults ages 20 to 25 years and people older than 60 years are most likely to have aplastic anemia. Men and women are equally affected. Most new cases in children are due to inherited bone marrow failure syndromes, caused by abnormal chromosomes. About four out of every 1 million people in the United States get aplastic anemia each year.

MDS affect more than 15,000 people in the United States each year. Researchers consider this number an underestimation resulting from challenges in classifying and reporting the syndromes. MDS are typically diagnosed between the ages of 70 and 80 years.

What causes aplastic anemia and MDS?

Although a cause is not found in most cases of aplastic anemia and MDS, the diseases may be triggered by exposure to:

- chemotherapy
- radiation therapy
- high levels of ionizing radiation—the type produced by high-power x-ray machines and in nuclear power plants
- benzene, a chemical used in some manufacturing processes
- toxic chemicals found in some pesticides
- certain viral infections

In most cases of aplastic anemia, these triggers, or other unknown causes, provoke the body’s own immune system to destroy the bone marrow stem cells. Certain rare, inherited bone marrow failure syndromes can also lead to aplastic anemia and MDS.

What are the symptoms of aplastic anemia and MDS?

Symptoms may include:

- fatigue
- weakness
- excessive bleeding, such as from external injuries or operations
- pinpoint red spots on the skin caused by bleeding from small blood vessels
- easy bruising
- frequent infections
- fevers
- pale skin
- shortness of breath

Symptoms vary depending on the person and the severity and type of disease. MDS often do not cause symptoms at first. Many of these symptoms also resemble those of other illnesses, making diagnosis difficult.
How are aplastic anemia and MDS diagnosed?

In addition to a medical history and physical exam, health care providers use blood tests, a bone marrow biopsy, and cytogenic analysis to diagnose aplastic anemia or MDS. A health care provider may refer a person to a hematologist—a doctor who treats diseases or disorders of the blood. A person also may be referred to an oncologist—a doctor who treats cancer—because aplastic anemia and MDS may be related to bone marrow cancers.

**Blood tests.** A blood test involves drawing a person’s blood at a health care provider’s office or a commercial facility and sending the sample to a lab for analysis. A complete blood count is usually the first test a health care provider uses to detect aplastic anemia or MDS. The test includes measurement of a person’s hematocrit, the percentage of the blood that consists of red blood cells. A complete blood count also measures

- the amount of hemoglobin in the blood
- whether a person has a lower-than-normal number of red blood cells
- whether a person has enough iron
- the number of white blood cells and platelets in the blood

Lower-than-normal numbers of one or more blood cell types may suggest aplastic anemia or MDS.

In another test called a peripheral blood smear, the health care provider examines a sample of blood with a microscope for unusual changes in the size, shape, and appearance of the blood cells. These cells usually appear normal in aplastic anemia; however, they may be abnormal in MDS.

A health care provider also may order blood tests to check for a shortage of folate, vitamin B12, and erythropoietin—a hormone made in the kidneys that stimulates the production of red blood cells.

**Bone marrow biopsy.** A health care provider needs results from a bone marrow biopsy to confirm the diagnosis of aplastic anemia or MDS. A biopsy is a procedure that involves taking a small piece of bone marrow, blood, and a small piece of bone for examination with a microscope. A health care provider performs the biopsy during an office visit or in a hospital and uses light sedation and local anesthetic. During the biopsy, the health care provider inserts a needle into the hip bone or breastbone. A pathologist—a doctor who specializes in diagnosing diseases—analyzes the bone marrow samples in a lab. The test can show abnormal cells, the number and type of blood progenitor cells, and levels of iron in the bone marrow.

**Cytogenic analysis.** This test involves sending the person’s bone marrow samples from the biopsy to a lab where a pathologist examines them with a microscope to look for abnormal changes in the person’s chromosomes.
How is aplastic anemia treated?

People with mild or moderate aplastic anemia may not need treatment at first. However, people with severe aplastic anemia need immediate medical treatment to prevent or reverse complications from having low blood cell levels. Treatment options, which a health care provider may use alone or in combination, include

- blood and bone marrow stem cell transplants, which require chemotherapy and radiation therapy
- medications
- blood transfusions

Treatment options depend on the age and general health of the person and the severity of the disease.

Blood and bone marrow stem cell transplants. Blood and bone marrow stem cell transplants, also called stem cell transplants, replace damaged stem cells in bone marrow with healthy stem cells from a donor’s blood or bone marrow and can cure aplastic anemia. Treatment guidelines state that stem cell transplant is the best treatment for people younger than 40 who have an available donor whose blood and bone marrow cells have been tested and found to “match” those of the patient. Umbilical cord blood collected from an umbilical cord and a placenta after a baby is born is frozen and stored at a cord blood bank for future use. Some people donate umbilical cord blood to a public cord blood bank, while others pay to store it at a private bank.

Before the transplant, a health care provider uses chemotherapy and sometimes radiation therapy to destroy a person’s own damaged bone marrow cells. These therapies also suppress a person’s immune system to prevent it from attacking the new stem cells after the transplant.

A health care provider confirms a matching donor by using a blood test called human leukocyte antigen tissue typing. Human leukocyte antigens are proteins found on the surface of white blood cells.

If health care providers do not find a matching donor in a person’s family, they will search the National Marrow Donor Program to look for other sources of stem cells for a transplant. Millions of volunteer donors are registered to provide a potential match. Health care providers look for

- donors who are a match and not family members
- family members who are close matches, although not exact
- unrelated donors who are close matches, although not exact
- umbilical cord blood that is a match
Chemotherapy and Radiation Therapy

Chemotherapy. Chemotherapy is a treatment that uses medications to stop the growth of immature blood cells, either by killing the cells or stopping them from dividing. A person can take chemotherapy medications by mouth or have them injected into cerebrospinal fluid or a vein, a muscle, an organ, or a body cavity, such as the abdomen. High doses can cause side effects such as nausea, vomiting, diarrhea, and fatigue. Treatment takes place in a hospital or chemotherapy treatment center. People may take oral chemotherapy medications at home. A team of health care providers, such as an oncologist and an oncology nurse, cares for people undergoing chemotherapy. A patient does not need anesthesia.

Radiation therapy. Radiation therapy is a treatment that uses external beams of either small doses of radiation over a period of time or a single, precise, high dose of radiation. Treatment takes place in a hospital or radiation treatment center. A team of health care providers, including a radiation oncologist—a doctor who specializes in treating tumors or cancer with radiation—cares for people receiving radiation therapy. Most people cannot feel radiation and do not require anesthesia. Side effects may include fatigue and skin sensitivity around the area being treated.

In a hospital, health care providers remove stem cells from the donor and freeze them for storage. If the donor stem cells are coming from the blood, the blood is removed from a large vein in the donor’s arm or through a central venous catheter, a flexible tube that is placed in a large vein in the neck, chest, or groin area. The blood goes through a machine that removes the stem cells. The blood is then returned to the donor and the health care provider stores the collected cells. If the donor stem cells are coming from the bone marrow, the health care provider will insert a hollow needle into the donor’s pelvis to withdraw the marrow. This procedure occurs in a hospital with local or general anesthesia and is less common.

After receiving chemotherapy or radiation therapy, a person receives the thawed donor stem cells through an intravenous (IV) line, a needle in a vein, or a central venous catheter. The stem cells then travel to the bone marrow where they re-establish and maintain normal blood cell production. The person may be given medication to relax. The transplant will take an hour or longer to complete. The catheter will stay in place for at least 6 months after the transplant, and the person will stay in the hospital from several weeks to months to ensure the transplant is successful. During this time, a person may easily develop an infection due to a weak immune system.
Stem cell transplants carry risks. A person’s immune system may attack the donated stem cells, called graft failure. Donated stem cells can attack the recipient’s body, called graft-versus-host disease. Both of these complications can be life threatening.

Read more in Bone Marrow Transplantation and Peripheral Blood Stem Cell Transplantation at www.cancer.gov.

**Medications.** Health care providers often prescribe one or more immunosuppressive medications, which suppress the immune system and reduce damage to bone marrow cells. Medications such as antithymocyte globulin may let the marrow start making blood cells again and reduce or eliminate the need for transfusions. In some people, blood counts return to normal. These medications are the preferred form of treatment for adults with severe aplastic anemia older than 40, younger patients who do not have a matched stem cell donor, and people with aplastic anemia who depend on blood transfusions.\(^5\) Taking these medications alone usually does not result in a cure. Corticosteroids, such as cyclosporine, are often given along with immunosuppressive medications to limit their side effects.

A person also may be given a man-made version of erythropoietin or a growth factor therapy that stimulates white blood cell production.

If infections due to low white blood cell counts occur, a health care provider may give the patient medications to kill bacteria, fungi, or viruses.

Health care providers often treat people with mild, inherited forms of aplastic anemia with man-made forms of androgens—male sex hormones that stimulate blood production. Androgens can help improve blood counts; however, they are not a cure.

**Blood transfusions.** A blood transfusion is a procedure in which a person receives healthy blood cells from a donor with the same blood type through an IV line. A health care provider performs the procedure during an office visit or in a hospital. The procedure lasts 1 to 4 hours, depending on how much blood the patient needs. Transfusions of red blood cells or platelets can raise blood cell counts and relieve symptoms. Transfusions are not a cure.

Most people with aplastic anemia need repeated transfusions, which can lead to complications. Over time, the body may develop antibodies that damage or destroy donor blood cells. Iron from transfused red blood cells can build up in the body and damage organs unless the health care provider prescribes medications called iron chelators to remove extra iron. Health care providers avoid giving a transfusion before a blood and bone marrow stem cell transplant because it increases the chances that the transplant will fail.
How are MDS treated?

Treatment options for MDS, which a health care provider may use alone or in combination, include supportive care, medications, chemotherapy, and blood and bone marrow stem cell transplants. Treatment options depend on the following:

- age and general health of the person
- whether the health care provider classifies MDS as a lower-risk or higher-risk disease
- whether the MDS occurred after chemotherapy or radiation therapy for another disease
- whether the MDS has worsened after being treated.

Supportive care. Traditionally the first line of treatment, supportive care aims to manage the symptoms of the disease. This approach may include blood transfusions to help problems caused by low blood cells counts, such as fatigue and infections, and may also include growth factor therapy.

Medications. A health care provider may give immunosuppressive medications such as lenalidomide (Revlimid) and antithymocyte globulin with or without cyclosporine to help the bone marrow function more normally. A person may need an iron chelator to treat too much iron in the blood. Some people also may benefit from erythropoietin. A health care provider may also give medications to fight infections with bacteria, fungi, or viruses.

Chemotherapy. A health care provider may give chemotherapy in an effort to destroy defective blood progenitor cells in severe MDS and let the few remaining normal blood stem cells re-establish normal blood cell production. Chemotherapy medications may include azacitidine (Vidaza), decitabine (Dacogen), or other anticancer medications. This approach is often not effective over the long term. A health care provider may also use chemotherapy prior to stem cell transplants.

Blood and bone marrow stem cell transplants. In the past, only a stem cell transplant with a matched sibling donor offered a cure for MDS. However, experts have made much progress with transplants from unrelated matched donors, including unrelated umbilical cord blood transplantation. In the past, health care providers did not routinely perform blood and bone marrow stem cell transplants for older adults with MDS. However, health care providers who are using newer techniques that use a less toxic pre-transplant regimen are performing successful blood and bone marrow stem cell transplants in this age group.
Eating, Diet, and Nutrition
Eating, diet, and nutrition have not been shown to play a role in preventing or treating aplastic anemia and MDS. However, people with either disorder who receive a stem cell transplant need to eat a healthy diet to help with their recovery. A person also may need to avoid some foods to lower the chances of infection while the immune system is still weak. A health care provider will advise a person on which specific foods to eat or avoid and when it is safe to eat in a restaurant. When dining out, stem cell transplant recipients should avoid foods that may be spoiled or not cleaned thoroughly, such as those at buffets or salad bars, to prevent infection.

Some people may not feel hungry, or medication side effects may make eating difficult or painful. Many people also may have nausea, diarrhea, or vomiting. People may need to eat or drink a nutritional supplement in the form of a shake or pudding. Eating foods high in potassium and magnesium will help replace these minerals if they are lost from diarrhea and vomiting. A health care provider also may suggest a person eat a diet high in phosphorus and calcium to strengthen and maintain bone health. Eating smaller, more frequent meals can help with nausea. Drinking enough water and other fluids daily is also important.

Stem cell transplant recipients may need to avoid alcohol to prevent reduced liver function. They may also need to avoid sodium, often from salt, to prevent high blood pressure and swelling.

Points to Remember
- Aplastic anemia and myelodysplastic syndromes (MDS) are rare and serious disorders that affect the bone marrow and blood.
- Young adults ages 20 to 25 years and people older than 60 years are most likely to have aplastic anemia. Most new cases of aplastic anemia in children are due to inherited bone marrow failure syndromes. MDS are typically diagnosed between the ages of 70 and 80 years.
- Although a cause is not found in most cases of aplastic anemia and MDS, the diseases may be triggered by exposure to
  - chemotherapy
  - radiation therapy
  - high levels of ionizing radiation—the type produced by high-power x-ray machines and in nuclear power plants
  - benzene
  - toxic chemicals
  - certain viral infections
- Certain rare, inherited bone marrow failure syndromes can also lead to aplastic anemia and MDS.
• Symptoms may include
  – fatigue
  – weakness
  – excessive bleeding
  – pinpoint red spots on the skin
  – easy bruising
  – frequent infections
  – fevers
  – pale skin
  – shortness of breath

• In addition to a medical history and physical exam, health care providers use blood tests, a bone marrow biopsy, and cytogenic analysis to diagnose aplastic anemia or MDS.

• People with mild or moderate aplastic anemia may not need treatment at first. However, people with severe aplastic anemia need immediate medical treatment to prevent or reverse complications from low blood cell levels. Treatment options, which a health care provider may use alone or in combination, include blood and bone marrow stem cell transplants, which require chemotherapy and radiation therapy; medications; and blood transfusions.

• Treatment options for MDS, which a health care provider may use alone or in combination, include supportive care, medications, chemotherapy, and blood and bone marrow stem cell transplants.

Hope through Research

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), through its Division of Kidney, Urologic, and Hematologic Diseases, conducts and supports research on aplastic anemia, MDS, and other blood diseases. This multifaceted hematology research program focuses on understanding basic cellular and molecular mechanisms that underlie the production and function of blood cells in health and disease.

The NIDDK Molecular Hematology Centers enrich research and generate investigative resources that can be made available to the broader research community. They often have integrated teams of investigators from a wide range of disciplines, share specialized equipment, and serve as regional or national resources. The Centers provide a focus for multidisciplinary investigations into gene structure and function; the cellular and molecular mechanisms involved in the generation, maturation, and function of blood cells; and the development of strategies for the correction of inherited diseases. For information about the Molecular Hematology Centers, visit www.niddk.nih.gov/research-funding.

Clinical trials are research studies involving people. Clinical trials look at safe and effective new ways to prevent, detect, or treat disease. Researchers also use clinical trials to look at other aspects of care, such as improving the quality of life for people with chronic illnesses. To learn more about clinical trials, why they matter, and how to participate, visit the NIH Clinical Research Trials and You website at www.nih.gov/health/clinicaltrials. For information about current studies, visit www.ClinicalTrials.gov.
References


For More Information

American Society of Hematology
2021 L Street NW, Suite 900
Washington, D.C. 20036
Phone: 202–776–0544
Fax: 202–776–0545
Internet: www.hematology.org

Aplastic Anemia & MDS International Foundation
100 Park Avenue, Suite 108
Rockville, MD 20850
Phone: 1–800–747–2820 or 301–279–7202
Fax: 301–279–7205
Email: help@aamds.org
Internet: www.aamds.org

Iron Disorders Institute
P.O. Box 675
Taylors, SC 29687
Email: cgarrison@irondisorders.org
Internet: www.irondisorders.org or www.hemochromatosis.org

National Center for Chronic Disease Prevention and Health Promotion
Centers for Disease Control and Prevention
4770 Buford Highway NE, Mailstop F–76
Atlanta, GA 30341–3717
Phone: 1–800–CDC–INFO (1–800–232–4636)
Internet: www.cdc.gov/nccdphp

National Heart, Lung, and Blood Institute Health Information Center
Attn: Website
P.O. Box 30105
Bethesda, MD 20824–0105
Phone: 301–592–8573
Telecommunications Relay Services: 7–1–1
Fax: 240–629–3246
Email: nhlbiinfo@nhlbi.nih.gov
Internet: www.nhlbi.nih.gov
Acknowledgments

Publications produced by the NIDDK are carefully reviewed by both NIDDK scientists and outside experts. This publication was originally reviewed by Phillip Scheinberg, M.D., and John Tisdale, M.D., National Heart, Lung, and Blood Institute, National Institutes of Health. Dr. Tisdale reviewed the updated version of this publication.

You may also find additional information about this topic by visiting MedlinePlus at [www.medlineplus.gov](http://www.medlineplus.gov).

This publication may contain information about medications and, when taken as prescribed, the conditions they treat. When prepared, this publication included the most current information available. For updates or for questions about any medications, contact the U.S. Food and Drug Administration toll-free at 1–888–INFO–FDA (1–888–463–6332) or visit [www.fda.gov](http://www.fda.gov). Consult your health care provider for more information.

The U.S. Government does not endorse or favor any specific commercial product or company. Trade, proprietary, or company names appearing in this document are used only because they are considered necessary in the context of the information provided. If a product is not mentioned, the omission does not mean or imply that the product is unsatisfactory.
National Hematologic Diseases Information Service

7 Information Way
Bethesda, MD 20892–3571
Phone: 1–888–828–0877
TTY: 1–866–569–1162
Fax: 703–738–4929
Email: hematologic@info.niddk.nih.gov
Internet: www.hematologic.niddk.nih.gov

The National Hematologic Diseases Information Service is an information dissemination service of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The NIDDK is part of the National Institutes of Health, which is part of the U.S. Department of Health and Human Services.

The NIDDK conducts and supports biomedical research. As a public service, the NIDDK has established information services to increase knowledge and understanding about health and disease among patients, health professionals, and the public.

This publication is not copyrighted. The NIDDK encourages users of this publication to duplicate and distribute as many copies as desired.

This publication is available at www.hematologic.niddk.nih.gov.