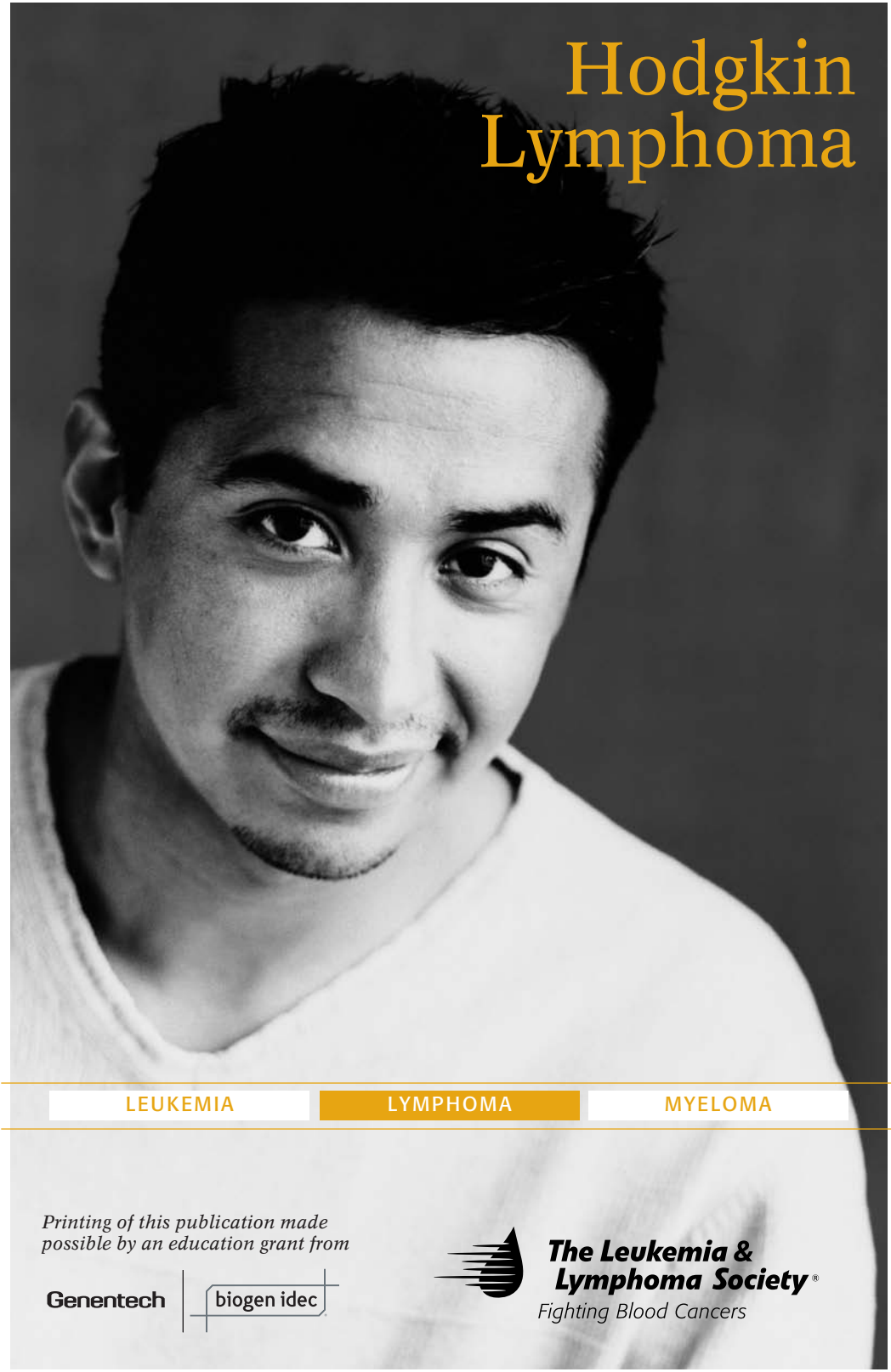
Hodgkin Lymphoma



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Fighting Blood Cancers

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Introduction

Lymphoma is a general name for a group of cancers that affect the lymphatic system. The two major types of lymphoma are Hodgkin lymphoma and non-Hodgkin lymphoma. Most forms of Hodgkin lymphoma are highly curable.

About 8,220 persons are expected to be diagnosed with Hodgkin lymphoma in 2008 in the United States. Hodgkin lymphoma is the eighth most common cancer among women 20 to 45 years and the eleventh most common cancer among men of the same age (source: Surveillance, Epidemiology, and End Results [SEER] Program; National Cancer Institute; 2008.)

Hodgkin Lymphoma provides information for patients, their families and caregivers. Brief descriptions of normal blood and marrow and the lymphatic system are provided for background. The descriptions are followed by detailed information about Hodgkin lymphoma. The booklet also contains information about important considerations before and after treatment to help provide greater quality of life for Hodgkin lymphoma survivors. We hope this information is of assistance, and we welcome comments about the booklet.

This booklet includes a glossary to help readers understand medical terms. Some of the medical terms used throughout this booklet may be synonyms for other words or phrases used by healthcare professionals. Check with your physician if you have questions about how the terms used in this booklet apply to you.

Normal Blood, Marrow and the Lymphatic System

Blood and Marrow. Blood is composed of plasma and cells suspended in it. Plasma is largely made up of water in which many chemicals are dissolved. These chemicals include

- Proteins, such as albumin; antibodies, including those developed by the body after vaccination (such as poliovirus antibodies); and clotting factors
- Hormones, such as thyroid hormones
- Minerals, such as iron, calcium, magnesium, sodium and potassium
- Vitamins, such as folate and B_{12}.

The cells suspended in plasma include red cells, platelets and white cells (neutrophils, eosinophils, basophils, monocytes and lymphocytes).

- Red cells make up about 40 to 45 percent of the blood. They are filled with hemoglobin, the protein that picks up oxygen in the lungs and delivers it to cells throughout the body.
- Platelets are small cell fragments, one-tenth the size of red cells, that help stop bleeding at the site of an injury in the body. For example, when a person gets a cut, the vessels that carry blood are torn open. Platelets stick to the torn surface of the vessel, clump together and plug up the bleeding site. A firm clot gradually forms. The vessel wall then heals at the site of the clot and returns to its normal state.
- Neutrophils (also called "polymorphonuclear leukocytes," "PMNs" or "polys") and monocytes are white cells. They are called "phagocytes" (eating cells) because they can ingest bacteria or fungi and kill them. Unlike the red cells and platelets, the white cells leave the blood and enter the tissues where they can ingest invading organisms and help combat infection. Eosinophils and basophils are two other types of white cells that respond to allergens.
- Most lymphocytes, another type of white cell, are in the lymph nodes, the spleen (an organ located in the left upper portion of the abdomen) and the lymphatic channels, but some enter the blood. There are three major types of lymphocytes: T cells, B cells and natural killer cells. These cells are key parts of the immune system.

Marrow is a spongy tissue in the central cavity of bones where blood cells develop. In newborns, 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 functioning marrow. The back bones (vertebrae), hip and shoulder bones, ribs, breastbone and skull contain marrow that makes blood cells in adults. Blood passes through the marrow and picks up formed red and white cells and platelets for circulation.

The process of blood cell formation is called "hematopoiesis." A small group of cells, the hematopoietic stem cells, develops into all the blood cells in the marrow by a process called "differentiation" (see Figure 1).

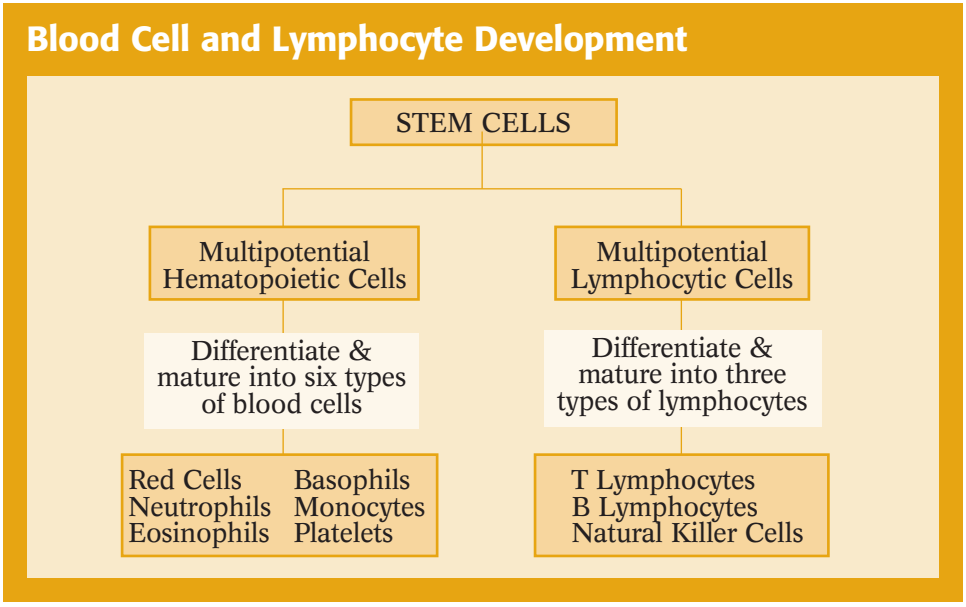


Figure 1. This simplified diagram depicts differentiation, the process in which stem cells develop into functional blood cells (hematopoiesis) and lymphatic cells.

When the fully developed and functional cells are formed, they leave the marrow and enter the blood. In healthy individuals, there are enough stem cells to keep producing new blood cells continuously. Some stem cells enter the blood and circulate. They are present in such small numbers that they cannot be counted or identified in the usual type of blood cell counts. However, their presence in the blood is important. If enough of these cells can be collected (using a special technique) from a compatible donor, they can be transplanted into a recipient whose own stem cells are unable to produce new blood cells. Stem cell circulation, from marrow to blood and back, also occurs in the fetus. After birth, placental and

umbilical cord blood can be collected, stored and used as a source of stem cells for transplantation. (To learn more about stem cell transplantation, see the free LLS booklet *Blood and Marrow Stem Cell Transplantation* and the fact sheet *Cord Blood Stem Cell Transplantation*.)

The Lymphatic System. The marrow is really two organs in one. The first is the blood cell-forming organ. The second is the lymphocyte-forming organ and is a part of the immune system.

The marrow produces three main types of lymphocytes:

- B lymphocytes (B cells), which make antibodies in response to foreign antigens, especially microbes.
- T lymphocytes (T cells), which develop in the thymus. The T lymphocytes have several functions, including assisting B lymphocytes to make antibodies against invading bacteria, viruses or other microbes. The antibody attaches to the microbe, making it possible for other white cells to recognize the antibody and pull (ingest) it into the cell along with its attached microbe. The white cell then kills and digests the microbe.
- Natural killer (NK) cells, which attack virus-infected cells without requiring antibody or other mediation. T cells and NK cells have other functions as well and are important elements in research efforts to design immunotherapies to treat lymphoma and other cancers.

The lymphocytes circulate through channels called "lymphatics," which connect the lymph nodes throughout the body to each other. The lymphatic channels collect into large ducts that empty into blood vessels. Lymphocytes enter the blood via these ducts. Most lymphocytes are found in the lymph nodes and other parts of the lymphatic system (see Table 1, page 5) such as the skin, spleen, tonsils and adenoids (special lymph nodes), intestinal lining, and, in young people, the thymus.

Table 1. Some Parts of the Lymphatic System

Lymph nodes	Gastrointestinal lymph areas
Plasma cells	Tonsils and adenoids
Lymphatic vessels	Natural killer cells
Spleen	T lymphocytes
Lymphokines	Marrow
B lymphocytes	Immunoglobulins

Table 1. Most lymphocytes are found in the lymph nodes and other parts of the lymphatic system such as the skin, spleen, tonsils and adenoids, and intestinal lining.

Hodgkin Lymphoma

Hodgkin lymphoma, one of the most curable forms of cancer, was named for the physician Thomas Hodgkin. In 1832, Dr. Hodgkin described several cases of people with symptoms of a cancer involving the lymph nodes. This disease was called "Hodgkin's disease" for about 170 years. It was officially renamed "Hodgkin lymphoma" in the late 20th century—when it became evident that the disease results from an injury to the DNA of a lymphocyte. The damage to the DNA is acquired (occurs after birth) rather than inherited. The altered DNA in the lymphocyte produces a cancerous change that—if untreated—results in the uncontrolled growth of the cancerous lymphocytes. The accumulation of the cancerous lymphocytes results in the tumor masses that are found in the lymph nodes and other sites in the body (see *Signs and Symptoms*, page 7).

Hodgkin lymphoma is distinguished from other types of lymphoma by the presence of "Reed-Sternberg cells" (named for the scientists who first identified them). Other cells associated with the disease are called "Hodgkin cells."

Incidence, Causes and Risk Factors

Incidence. Hodgkin lymphoma is most likely to be diagnosed in people in their twenties or early thirties. It is less common in middle age but becomes more common again after age 65 (see Figure 2).

Hodgkin Lymphoma
Age-Specific Incidence Rates (2001-2005)

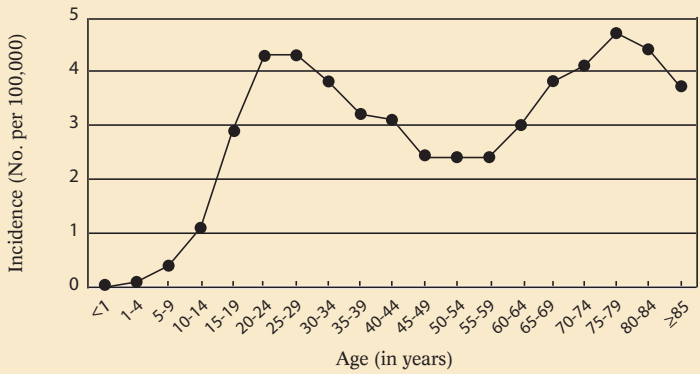


Figure 2. The horizontal axis shows 5-year age intervals. The vertical axis shows the frequency of new cases of Hodgkin lymphoma per 100,000 people, by age-group. Incidence of Hodgkin lymphoma peaks at ages 15 to 44 and at age 60 and older (source: Surveillance, Epidemiology and End Results [SEER] Program; National Cancer Institute; 2008).

Causes and Risk Factors. Most cases of Hodgkin lymphoma occur in people who do not have identifiable risk factors; most people with identifiable risk factors do not develop Hodgkin lymphoma. The following are examples of risk factors.

- A history of serologically confirmed infectious mononucleosis confers a threefold increased risk of young-adult Hodgkin lymphoma compared to the risk incurred by the general population.
- People infected with human T-cell lymphocytotropic virus (HTLV) or human immunodeficiency virus (HIV) also have increased probability of developing Hodgkin lymphoma.

- There are occasional cases of familial clustering, as with many cancers, and there is an increase in the incidence of Hodgkin lymphoma in siblings of patients with the disease. These cases are uncommon, but the concept of genetic predisposition is under study to determine its role in the sporadic occurrence of Hodgkin lymphoma in otherwise healthy individuals. (For more information see, "Other Disease Studies" under "Clinical Trials Service" at www.LLS.org or contact the Information Resource Center at [800] 955-4572.)

The results of certain studies about causes of Hodgkin lymphoma have not been definitive. For example:

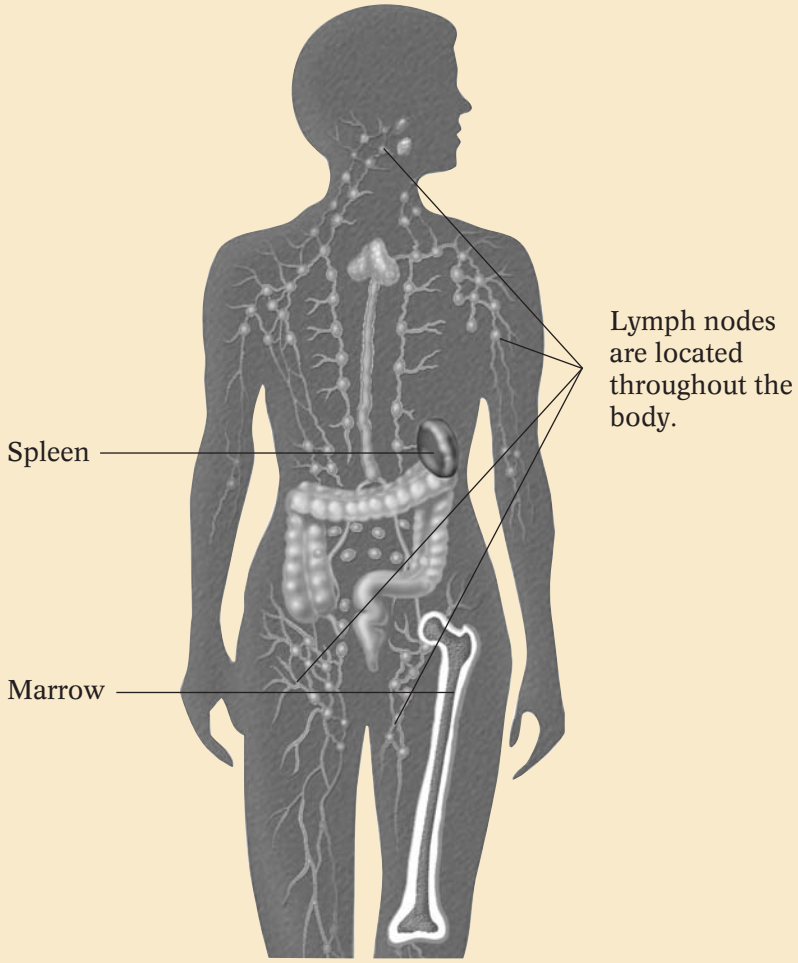
- Many studies of links between Hodgkin lymphoma and environmental, especially occupational, exposures have been conducted, with unclear results.
- Epstein-Barr virus has been associated with nearly half of cases. However, this virus has not been conclusively established as a cause of Hodgkin lymphoma.

Signs and Symptoms

The most common early sign of Hodgkin lymphoma is a painless swelling (enlargement) of one or more lymph nodes. The vast majority of patients with Hodgkin lymphoma have affected lymph nodes in the upper part of the body—usually in the neck or upper chest. Sometimes the affected lymph node is in the armpit, abdomen or groin.

There are about 600 lymph nodes in the body (see Figure 3, page 8).

Hodgkin Lymphoma and the Lymphatic System



The lymphatic system is part of the immune system. The normal immune system helps to protect the body from infection. The marrow, lymph nodes, lymphocytes and spleen are some of the parts of the immune system. There are about 600 lymph nodes throughout the body.

Figure 3. Lymph nodes and other lymphoid tissues that are commonly involved in lymphoma are those around the ears and jaw, in the tonsils and adenoids, in the front and back of the neck, above and below the collar bone, in the armpit, near the elbow, in the chest, in the abdomen, in the pelvis and in the groin. The spleen contains many clusters of lymphocytes that can become malignant and grow, leading to the enlargement of the spleen. The gut-associated (intestinal) lymph tissue may also be the site of lymphoma development.

Other Hodgkin lymphoma symptoms include

- Fever
- Persistent cough and shortness of breath (if Hodgkin lymphoma is located in the chest)
- Sweating, especially at night (drenching sweats of the whole body, not just the neck area or chest area)
- Weight loss
- Itching.

Persons with Hodgkin lymphoma may experience pain in the lymph nodes after drinking alcohol—this is an uncommon but specific symptom. The spleen may be enlarged.

Diagnosis

Imaging. A physician may first order imaging tests (see the discussion on imaging in *Staging*, page 12) when a patient's medical history and physical examination suggest a possible diagnosis of Hodgkin lymphoma. The imaging test(s) may show enlarged lymph nodes in the chest or abdomen or both. Tumor masses can also occur outside the lymph nodes in lung, bone or other body tissue.

Lymph node biopsy. The diagnosis of Hodgkin lymphoma can be difficult and requires an experienced hematopathologist (a physician who specializes in interpreting and diagnosing the physical changes caused by diseases of the blood and marrow) to analyze the biopsy slides. Hodgkin lymphoma can be confused with various types of non-Hodgkin lymphoma—since the treatment is different, a precise diagnosis is needed. Keep in mind that another opinion by a second hematopathologist may be necessary if there is any doubt about the diagnosis.

A biopsy of an involved lymph node or other tumor site is needed to confirm the diagnosis of Hodgkin lymphoma. A needle biopsy of the lymph node is usually not sufficient to make a firm diagnosis. The lymph node or part of the lymph node is surgically removed so that the hematopathologist has enough tissue to make a firm diagnosis.

Lymph node tissue for biopsy can often be removed using a local anesthetic. Chest or abdominal surgery is occasionally necessary for diagnosis and requires general anesthesia. Newer minimally invasive approaches using a thin, lighted tube called a "laparoscope" permit biopsies within body cavities without major incisions or manipulations.

The hematopathologist prepares a slide from the biopsy specimen by placing the tissue in preservative and staining it with dyes. The cells on the slide are examined under a microscope. The distinctive patterns of lymph node changes characteristic of Hodgkin lymphoma are visible under the microscope and can help the pathologist categorize the patient's Hodgkin lymphoma into one of several subtypes (see Table 2, page 11).

Immunophenotyping. A technique called "immunophenotyping" is sometimes used to distinguish Hodgkin lymphoma from other types of lymphoma or other noncancerous conditions. The hematopathologist looks for the presence of Reed-Sternberg and Hodgkin cells to confirm a diagnosis of Hodgkin lymphoma.

Subtypes of Hodgkin Lymphoma

Knowing the patient's subtype is important for making treatment decisions. There are two main Hodgkin lymphoma subtypes (see Table 2, page 11). About 95 percent of patients with Hodgkin lymphoma have classic Hodgkin lymphoma. The other main type is nodular lymphocyte-predominant Hodgkin lymphoma.

Classic Hodgkin lymphoma can be further subdivided. The nodular sclerosis subtype of classic Hodgkin lymphoma is the most common type in young adults (15-34 years). The mixed cellularity subtype of classic Hodgkin lymphoma is more common in children (0-14 years) and older adults (55-74 years). Both types are highly curable.

Classic Hodgkin Lymphoma. Four major subtypes of classic Hodgkin lymphoma have been identified. They are

- *Nodular Sclerosis.* Nodular sclerosis is the most common subtype, representing about 60 to 70 percent of Hodgkin lymphoma cases. Younger patients are more likely to have this type. The nodes first affected are often those located in the center of the chest (the mediastinum). It is characterized by fibrous tissue, visible under the microscope, among the Hodgkin cells. This type of tissue forms scars,

and sometimes after treatment there can be persistent abnormalities, such as small lumps. These may be benign, consisting of scar tissue (also called "residual fibrosis") that remains after the disease cells have been eliminated.

- *Mixed Cellularity.* Mixed cellularity is the second most common subtype. It occurs in about 25 percent of patients and mostly in older patients, children, and those with immune disorders, such as AIDS. It is a somewhat more aggressive subtype, although just as curable, as nodular sclerosis Hodgkin lymphoma.
- *Lymphocyte-Depleted.* The lymphocyte-depleted subtype occurs in about 4 percent of patients, nearly always in older patients. It usually indicates extensive disease with a relatively poor outlook and may be misdiagnosed as non-Hodgkin lymphoma.
- *Lymphocyte-Rich Classic.* This subtype is similar to the nodular lymphocyte-predominant subtype but has more characteristics in common with classic Hodgkin lymphoma.

Nodular Lymphocyte-Predominant Hodgkin Lymphoma. The nodular lymphocyte-predominant (NLPHL) subtype occurs in about 5 percent of patients. The cells in NLPHL, known as "lymphocytic" and "histolytic" cells, are different from classic Reed-Sternberg B cells. Patients with this subtype may have no symptoms and are usually diagnosed with very limited disease. It is most common in young men. The NLPHL subtype is indolent (slow-growing) and is associated with long-term survival. However, there is a 3 percent risk that this subtype will transform to non-Hodgkin lymphoma. The treatment is somewhat different from the treatment for other subtypes (see *Nodular Lymphocyte-Predominant Hodgkin Lymphoma Treatment,* page 20).

Table 2. Subtypes of Hodgkin Lymphoma

Classic Hodgkin lymphoma
- Nodular sclerosis Hodgkin lymphoma
- Mixed cellularity Hodgkin lymphoma
- Lymphocyte-depleted Hodgkin lymphoma
- Lymphocyte-rich classic Hodgkin lymphoma

Nodular lymphocyte-predominant Hodgkin lymphoma

Table 2. The World Health Organization (WHO), which influences disease classification throughout the world, has designated several subtypes of Hodgkin lymphoma.

Staging

A physical examination and imaging tests (also called "diagnostic radiology") are used to determine the extent of the disease. This is called "staging." Staging provides important information for treatment planning. The staging system commonly used for Hodgkin lymphoma is the Modified Ann Arbor Staging System.

Physical Examination and Imaging Tests. The physical exam and imaging tests help the physician to evaluate

- The location and distribution of lymph node enlargement
- Whether organs other than lymph nodes are involved
- Whether there are very large masses of tumors in one site or another.

Imaging tests include

- Chest x-ray
- Computed tomography (CT) scan of the chest, abdomen and pelvis
- Magnetic resonance imaging (MRI)
- [18F] Fluorodeoxyglucose positron emission tomography (FDG-PET) (whole body).

In many centers, patients have CT scans of the neck, chest, abdomen and pelvis—all the areas where lymph nodes are present—to see whether there are other areas of disease. The CT scan can also show whether there is involvement of the lungs, liver and other organs, information that is helpful in staging (see Table 3, page 13 and Figure 4, page 14).

The use of PET or PET/CT scans in managing Hodgkin lymphoma is becoming more common. Currently, PET is widely used for response assessment after completion of therapy. It is used to a lesser extent for pretreatment staging and assessment of response during therapy. PET cannot replace CT scan or bone marrow biopsy in staging Hodgkin lymphoma. However, it can provide complementary information.

Table 3. Stages and Categories of Hodgkin Lymphoma

Stage I
Apparent involvement of a single lymph node region or a single organ, such as bone.

Stage II
Involvement of two or three lymph node regions that are close to each other; for example, all in the neck and chest, or all in the abdomen and on the same side of the diaphragm (a thin muscle below the lungs).

Stage III
Involvement of several lymph node regions in the neck, chest and abdomen (on both sides of the diaphragm).

Stage IV
Widespread involvement of lymph nodes on both sides of the diaphragm and other organs, such as the lungs, liver and bones.

Categories A and B. The four stages of Hodgkin lymphoma can be divided into A and B categories.

- The A category indicates the absence of fever, exaggerated sweating and weight loss.
- The B category indicates that patients have fever, excessive sweating and weight loss. For example, stage IIB indicates that the patient has
  - Two lymph node sites near each other with disease involvement (for example, enlarged lymph nodes in the neck and near the collarbone, or in the neck and the armpit)
  - Fever, excessive sweating and weight loss.

Patients in the B category often require more aggressive treatment.

Table 3. The stage and the presence of symptoms determine whether radiation therapy, chemotherapy or both are recommended for treatment (see Table 4, page 16).

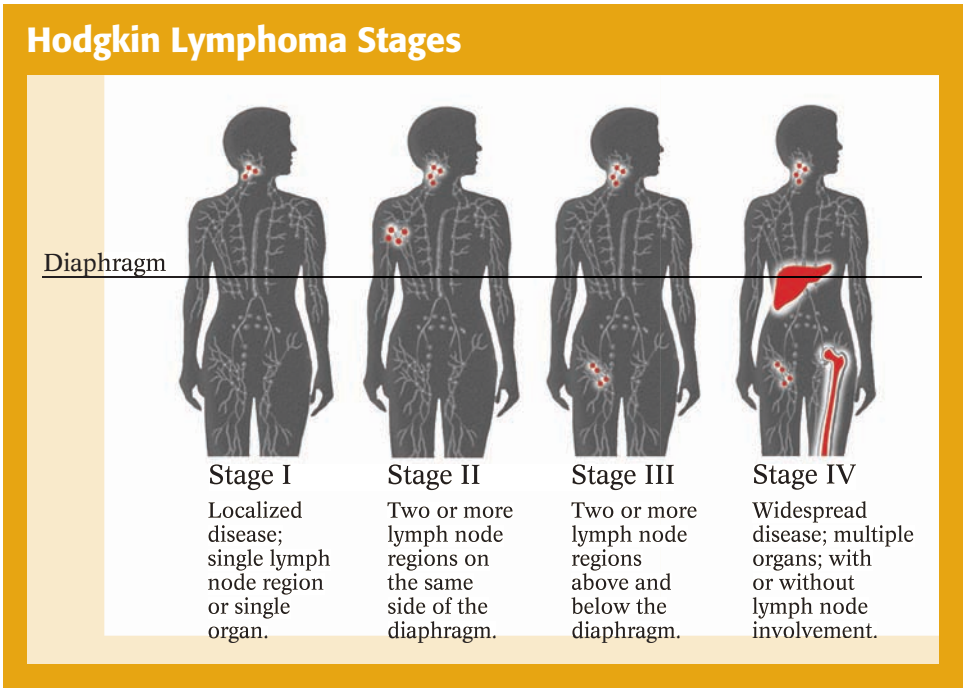


Figure 4. This illustration shows the location of Hodgkin lymphoma in the body for each stage. The stages are described in Table 3, page 13.

Blood and Marrow Tests. Patients also have blood cell counts and other blood tests to check indicators of disease severity such as blood protein levels, uric acid levels, erythrocyte sedimentation rate (ESR) and liver functions.

Many patients who are diagnosed with Hodgkin lymphoma will have a bone marrow biopsy to make sure that there is no spread of the disease to the bone marrow. A bone marrow biopsy may not be required for patients with early-stage disease and low-risk clinical features (such as no symptoms of fever, night sweats, weight loss or bulky disease [large masses of lymphocytes]).

Treatment

Cure is the goal of treatment for patients with Hodgkin lymphoma. More than 75 percent of all patients diagnosed with Hodgkin lymphoma can be cured by current treatment approaches. The cure rate is higher, approaching 90 percent, in all younger patients.

Treatment Planning. Treatment planning factors for Hodgkin lymphoma patients include

- Disease subtype
- Disease stage and category
- Refractory or relapsed disease
- Patient age and coexisting diseases or conditions (for example, severe anemia, heart or kidney disease, diabetes).

Clinical trials to identify other prognostic indications for Hodgkin lymphoma patients are under way. See *Research and Clinical Trials* beginning on page 23.

Pretreatment Considerations. Adults of childbearing age and parents of children diagnosed with Hodgkin lymphoma should ask their physicians for information that may lessen the risk for infertility. See the free LLS fact sheet *Fertility Facts* for more details.

Treatment Approaches. "Involved field" radiation therapy with chemotherapy (sometimes called "combined modality therapy") is the most common treatment approach for Hodgkin lymphoma. Involved field radiation therapy targets the evident Hodgkin lymphoma cell masses, and chemotherapy is used to kill neighboring lymphoma cells.

Radiation therapy involves the use of special machines that produce high-energy rays capable of killing the Hodgkin lymphoma cells. Continuous improvements in the devices that deliver radiation therapy have led to more precise targeting of treatment areas. In addition, the uninvolved organs, such as the lungs, liver and reproductive organs, are shielded to help minimize the side effects of the treatment.

Chemotherapy may be given without radiation therapy for patients with widespread disease, fever, drenching night sweats and/or weight loss (see Table 4, page 16).

Table 4. Some Treatment Approaches for Hodgkin Lymphoma

- Combination chemotherapy with or without involved field radiation
- Chemotherapy combinations
  - ABVD (Adriamycin® [doxorubicin], bleomycin, vinblastine and dacarbazine)
  - BEACOPP (bleomycin, etoposide, Adriamycin® [doxorubicin], cyclophosphamide, Oncovin® [vincristine], procarbazine and prednisone)
  - Stanford V (mechlorethamine [Mustargen®], doxorubicin, vinblastine, vincristine, bleomycin, etoposide and prednisone)
- High-dose chemotherapy with stem cell transplantation

See *Treatment Side Effects,* page 22.

Chemotherapy usually involves at least four drugs given in combination. The drugs are dissolved in fluid and usually administered to the patient through a peripheral intravenous (IV) line. It is possible that a port, a central line or a percutaneously inserted central venous catheter—known as a PICC or a PIC line—may be used for some Hodgkin lymphoma patients.

Treatment Setting. Radiation therapy and chemotherapy can be administered in an outpatient clinic of an oncology center. Short periods of hospitalization are sometimes necessary. For example, if therapy is particularly intensive, it may result in prolonged or severe decreases in red cell, white cell and/or platelet counts. Transfusion of appropriate blood products and administration of blood cell growth factors to enhance blood cell production may be needed. Even in these cases, outpatient treatment may still be feasible. Patients undergoing autologous stem cell transplantation may be hospitalized. Patients undergoing allogeneic stem cell transplantation are hospitalized.

Stage I and Stage II Hodgkin Lymphoma. The cure rate for stages I and II Hodgkin lymphoma exceeds 95 percent. The current treatment approach is to give reduced amounts of radiation with chemotherapy. This approach has resulted in less toxicity and improved outcome. ABVD (Adriamycin® [doxorubicin], bleomycin, vinblastine and dacarbazine) is the first choice for most adult patients who need chemotherapy. It is the most effective and least toxic regimen available to date. ABVD poses less of a risk for leukemia or infertility than other adult combinations.

Current practice guidelines for treatment of early-stage, low-risk Hodgkin lymphoma suggest that about 95 percent of patients can be cured with as few as two courses of ABVD, followed by involved field radiation with a reduced dose of radiation. Results of some clinical trials indicate that the vast majority of patients with stages I and II Hodgkin lymphoma could benefit from chemotherapy alone, with about an 85 percent cure rate.

Stages I and II patients with higher risk generally require at least four to six cycles of ABVD, also followed by involved field radiation.

See *Nodular Lymphocyte-Predominant Hodgkin Lymphoma Treatment* on page 20 for more information about this subtype.

Advanced Hodgkin Lymphoma. Hodgkin lymphoma is potentially curable in late stages. In general, patients with stage III or IV disease are treated with combination chemotherapy such as six to eight courses of ABVD or BEACOPP (bleomycin, etoposide, Adriamycin® [doxorubicin], cyclophosphamide, Oncovin® [vincristine], procarbazine and prednisone).

BEACOPP results in a good cure rate but carries a small risk of leukemia or other second cancers. For this reason it is a less common treatment in the United States and Canada. It may be used for patients with very aggressive presentations of advanced Hodgkin lymphoma.

Stanford V (mechlorethamine, doxorubicin, vinblastine, vincristine, bleomycin, etoposide and prednisone) with or without radiation therapy is another combination chemotherapy for advanced Hodgkin lymphoma. It is given over a shorter time but more frequently than ABVD. This regimen is effective for extensive and advanced disease. However, more data are needed in order know whether it is superior to ABVD or other therapies.

The International Prognostic Factors for Advanced Hodgkin Lymphoma. Several years ago an international consortium pooled patient data and identified a prognostic score for advanced Hodgkin lymphoma patients based on seven factors. These factors provide a basis for recommending either more or less aggressive treatment, including stem cell transplantation, for high-risk patients. The International Prognostic Factors for Advanced Hodgkin Lymphoma also promotes uniformity in clinical trial design and evaluation (see Table 5).

Table 5. International Prognostic Factors for Advanced Hodgkin Lymphoma

Higher risk is associated with these seven factors—the more factors present, the greater the risk.

The patient is

- Male
- 45 years or older.

The patient has

- Stage IV disease
- Hemoglobin of less than 10.5 g/dL
- White blood cell (WBC) count of 15,000/µL or higher
- Lymphocyte count less than 600/µL and/or less than 8 percent of the total WBC count
- Albumin of less than 4 g/dL.

Treatment Response Monitoring. FDG-positron emission tomography (PET) provides more accurate information for treatment response assessment than CT scanning because PET images distinguish between tumor and fibrous tissue.

Posttherapy Surveillance. Periodic examination for recurrence in Hodgkin lymphoma patients is necessary for years after treatment. Chest x-rays and CT scans of the abdomen are used to detect relapsed disease. The role of PET for ongoing posttherapy surveillance without clinical, biochemical or radiographic evidence of disease needs further study to determine whether routine surveillance by PET is superior to standard surveillance methods.

Patients also need to be monitored for long-term and late effects of treatment (see *Long-Term and Late Effects of Treatment*, page 25).

Relapsed or Refractory Hodgkin Lymphoma. ABVD results in disease regression in the vast majority of patients. However, a small percentage of patients have disease that does not respond to initial treatment (called "refractory Hodgkin lymphoma"). Less then 10 percent of patients respond only briefly or do not respond to ABVD and experience disease progression. These patients require treatment with high-dose chemotherapy with stem cell transplantation.

For patients who relapse after treatment, Hodgkin lymphoma is still potentially curable even in these cases.

High-dose Chemotherapy with Stem Cell Transplantation. Stem cell transplantation may provide a cure for some patients with relapsed Hodgkin lymphoma.

Currently, high-dose chemotherapy with stem cell transplantation is not recommended for initial treatment because

- The results of treatment with primary ABVD or BEACOPP are so good
- High-dose chemotherapy and stem cell transplantation are higher-risk treatments with greater toxicity.

Autologous Stem Cell Transplantation. High-dose chemotherapy with autologous stem cell transplantation is used routinely for many patients in first relapse. With this treatment, disease-free survival rates of 40 to 50 percent are expected at 5 years, and transplant mortality is less than 5 percent.

Allogeneic Stem Cell Transplantation. Some patients with multiply-relapsed Hodgkin lymphoma have been treated successfully with allogeneic stem cell transplantation. However, this treatment has a significant risk of mortality. Clinical trials are under way for treating relapsed patients with a form of allogeneic transplant called "reduced-intensity stem cell transplant" (see page 26). More study is needed to determine the effectiveness of this treatment for Hodgkin lymphoma patients.

See the free LLS booklet *Blood and Marrow Stem Cell Transplantation* for more information about autologous and allogeneic stem cell transplants.

Nodular Lymphocyte-Predominant Hodgkin Lymphoma Treatment. Patients with this subtype of Hodgkin lymphoma need different treatment than patients with classic Hodgkin lymphoma. Almost 80 percent of patients with nodular lymphocyte-predominant Hodgkin lymphoma are diagnosed with stage I disease.

This subtype is an indolent (slow-growing) form of Hodgkin lymphoma. It is associated with close to 100 percent long-term survival and it is important not to overtreat these patients. At present, the treatment for patients with nodular lymphocyte-predominant Hodgkin lymphoma is involved field radiation alone. Although patients do respond to chemotherapy, the disease tends to recur more often after chemotherapy.

Childhood Hodgkin Lymphoma. The incidence of Hodgkin lymphoma in children and young adults under the age of 20 was 1.1 per 100,000 in 2005 (the most recent data available). The 5-year survival rate for patients younger than 20 years is 95 percent.

It is important for young adults and parents of children diagnosed with Hodgkin lymphoma to talk to members of the oncology team about the

- Stage of the disease (see page 12)
- Specific subtype of the disease (see page 10)
- Other potential risk factors, such as certain laboratory test values.
- The rate of response to treatment, which physicians measure using imaging techniques such as PET and PET-CT.

Physicians use this information about the patient's disease in order to determine the most effective therapy. The main treatment advancement in recent times is the ability of physicians to develop treatment plans that limit the amount of therapy required to bring about remission. It is important to discuss the planned therapy with members of the oncology team to learn about the drugs, potential side effects and long-term effects and the treatment schedule. See *Pretreatment Considerations* on page 15.

Children and young adults with Hodgkin lymphoma are usually treated with combination chemotherapy, sometimes with the addition of radiation therapy to increase local control of the disease. The following are some of the combinations that may be used:

- COPP (Cytoxan®, Oncovin®, prednisone and procarbazine)
- ABVD (Adriamycin®, bleomycin, vinblastine and dacarbazine)
- COPP-ABV (Cytoxan®, Oncovin®, prednisone and procarbazine, Adriamycin®, bleomycin, vinblastine)
- CHOP (Cytoxan®, hydroxydaunomycin, Oncovin® and prednisone).

Other combinations including BEACOPP and Stanford V (see Table 4, page 16) may also be used. The free LLS booklet *Understanding Drug Therapy and Managing Side Effects* has more information about the individual drugs and side effects.

Advances in treating childhood Hodgkin lymphoma, by improving the cure rate and the quality of the life for survivors, are in large part due to the research of pediatric cooperative groups. The focus of ongoing research and clinical trials is to

- Further improve the cure rate, especially for children with advanced Hodgkin lymphoma such as IIIB and stage IV
- Minimize the risk of long-term and late effects associated with treatment (for example, infertility, impaired cardiac function and second cancers).

Treatment Outcome Summary. Many Hodgkin lymphoma patients are cured after initial treatment. For the smaller number of patients who may have disease recurrence or relapse, additional treatment with chemotherapy, sometimes in combination with stem cell transplantation, is often successful. A large number of these patients are cured or have very prolonged disease-free periods after undergoing a subsequent treatment regimen.

See *Research and Clinical Trials* on page 23 for more information about treatment for all types of Hodgkin lymphoma.

Treatment Side Effects

Infections. One of the important features of Hodgkin lymphoma is a decrease in the immune system's function. The cells of the immune system do not react normally. This situation can make patients susceptible to certain types of infection. Herpes zoster (also known as "shingles") is an example of a viral disease that occurs with increased frequency in patients with Hodgkin lymphoma. The effects of chemotherapy and radiation therapy can enhance susceptibility to infection since these treatments add to the suppression of immune cell function. Removal of the spleen, now performed less often, also contributes to the risk of severe infections. However, when patients are cured, their immune function may improve. In addition, improvement in the treatment of patients with Hodgkin lymphoma, increased awareness of the risk of infectious diseases, and the availability of better antimicrobial therapy has made infectious complications less of a medical problem for patients.

Other side effects depend on the intensity and type of chemotherapy, the location of the radiation therapy, the age of the patient and coexisting medical conditions (diabetes, chronic kidney disease and others). In recent years, new drugs have increased physicians' ability to control nausea and vomiting and other side effects.

Suppressed Blood Cell Formation. Blood cell counts can fall in patients treated with chemotherapy, and patients may require blood transfusions. If white cell counts drop severely and for extended periods of time, patients may develop infections and require antibiotic treatment. To allow the patient's blood counts to recover from the effects of treatment, doses of chemotherapy or the time between chemotherapy cycles is sometimes altered, or drugs such as granulocyte-colony stimulating factor (G-CSF) are given.

See the free LLS booklet *Blood Transfusion* for more information.

Effects on Fertility. Patients may be less fertile after treatment. The risk of infertility varies according to the nature of the treatment—the type and amount of chemotherapy, the location of radiation therapy and the patient's age. Men who are at risk of infertility can consider sperm banking before treatment. Women who have ovarian failure after treatment will experience premature menopause and require hormone replacement therapy. In couples of childbearing age where one partner has received treatment, the incidence of fetal loss and the health of the newborn are very similar to those of healthy couples.

Other Effects. Treatment may cause nausea, vomiting, diarrhea, extreme fatigue, fever, cough or hair loss. These and other potential effects depend on the drugs and dosages used and on the individual patient's susceptibility. When side effects do occur, most are temporary and resolve when therapy is completed. Certain drugs have a specific tendency to affect certain tissues (for example, vincristine tends to affect nervous tissue and bleomycin may affect the lungs). For specific drug information see the free LLS booklet *Understanding Drug Therapy and Managing Side Effects.*

Research and Clinical Trials

LLS Research Program. LLS invests research funds in both basic and applied research programs for Hodgkin lymphoma and other blood cancers.
LLS is funding a population-based study to identify genes and cell proteins that govern immune response in young adult Hodgkin lymphoma. This work may lead to a greater understanding of low-risk and high-risk Hodgkin lymphoma. Another LLS-funded study to understand how Hodgkin lymphoma cells evade the body's immune response mechanisms is under way. The study may lead to the identification of new targeted therapies.

Clinical Trials. Multiphase clinical trials for new treatments are carefully planned and monitored research studies, conducted by physicians and medical researchers. In a phase 1 trial, a relatively small number of patients are studied to assess dosage, patient tolerance and acute toxic effects for a new treatment. In a phase 2 trial, more patients are studied to gather additional information about dosage, effects and toxicity. In a phase 3 trial, the treatment is compared in larger numbers of patients, who are randomized to receive the existing best treatment or the new (study) treatment. Phase 4 studies are conducted for new drugs or treatments that already have approval of the Food and Drug Administration (FDA). The goals are to identify additional uses for the drug or treatment, gather additional safety and effectiveness information from a larger group of patients, and establish effectiveness in specific subgroups of patients—for example, in patients older than 65 years.

Clinical trials are under way to study treatments for newly diagnosed patients—or patients with relapsed or refractory disease. Clinical trials can involve new drugs, new combinations of drugs or approved drugs that are being studied to treat patients in new ways.

There are several types of studies to improve the care of Hodgkin lymphoma, including studies to address causes, risk factors and quality of life issues. Examples of the questions that studies seek to answer are shown in Table 6.

Table 6. Study Questions for Hodgkin Lymphoma Clinical Trials

- How can we lower the risk of long-term and late effects of treatment?
- What can we learn about biomarkers and genetic causes of Hodgkin lymphoma (familial clustering) that may lead to a better understanding of causes, risk factors and less toxic treatments?
- How can we improve the quality of life for the many survivors of Hodgkin lymphoma?
- Can we develop more effective and less toxic treatments for patients with advanced, relapsed or refractory Hodgkin lymphoma?
- Can new approaches to stem cell transplantation make this therapy safer, especially for older and sicker patients?
- What is the role of vaccine therapy in the treatment of Hodgkin lymphoma?

The Information Resource Center at LLS, (800) 955-4572, offers guidance on how patients can work with their physicians to find out if a specific clinical trial is an appropriate treatment option. Information Specialists will conduct individualized clinical trial searches for patients, family members and healthcare professionals. This service is also available on the Web site at www.LLS.org.

Table 6. Many different questions are being addressed in ongoing clinical trials. Patient participation is needed. For more information speak to your physician or contact an Information Specialist at LLS.

Long-term and Late Effects of Treatment. There is considerable interest in studying the use of chemotherapy alone for the treatment of patients with early-stage Hodgkin lymphoma. Several studies have been conducted with results suggesting chemotherapy alone is a viable approach. Studies in this area include

- Comparing outcomes between the use of chemotherapy alone to the use of combined modality therapy (chemotherapy with involved field radiation therapy)
- Collecting and analyzing data on the long-term side effects of ABVD and involved field radiation therapy.

Interim PET/CT as Decision Tool for Chemotherapy Adjustment. Recent studies comparing different chemotherapy regimens such as ABVD and BEACOPP have led to new challenges to identify clinical or biological prognostic factors that may help physicians recognize those patients who will benefit most from more intensive treatment. Further studies are under way to address the challenges for using PET to assess the benefits of specific therapies (risk-adapted therapies) for individual patients.

Biomarkers and Genetic Causes. Studies are under way to identify biological markers, called "biomarkers," which are high levels of substances that are released by cancer cells. Biomarkers can be used to get information about the presence and level of cancer cells. Biomarkers under investigation in Hodgkin lymphoma include

- CD44, a molecule that binds to the surface of cells. High levels of CD44 may suggest more aggressive disease.
- Interleukin (IL) 10, an immune factor. High levels of IL10 may indicate a relatively poor outlook.

Studies of familial Hodgkin lymphoma are under way to obtain a better understanding of the genetic causes of Hodgkin lymphoma. The goal is to identify genetic changes that may lead to the ability to predict a person's risk of developing Hodgkin lymphoma.

Quality of Life Studies. There are more than 100,000 Hodgkin lymphoma survivors in the United States alone. Several studies have described long-term effects of therapy, including second cancers, heart disease and depression among Hodgkin lymphoma survivors. A great deal is known about the late effects Hodgkin lymphoma that was diagnosed and treated before 1987. In part, as a result of that knowledge, treatment was changed in the late 1980s to decrease the risk of long-term effects. Investigators are now gathering information on any long-term or late effects among

survivors who were treated in the past 20 years. The goal is to provide less toxic treatments for people who are diagnosed in the future, while maintaining or improving the cure rates of standard therapy. This information will be also used to propose guidelines for long-term follow-up care for survivors. Study participants may be asked to complete questionnaires about their medical health and quality of life (such as energy level, outlook on life and any long-term physical effects of the disease).

Advanced, Relapsed or Refractory Hodgkin Lymphoma. Several chemotherapy regimens, with and without targeted therapies, are being studied for effectiveness and safety in advanced, relapsed or refractory disease. Examples of studies include comparisons of outcomes between various combinations of chemotherapy with or without new drugs and antibodies. Adding new agents to chemotherapy regimens may mean that patients can receive reduced amounts of chemotherapy, thereby reducing side effects.

Stem Cell Transplantation. A number of studies are in progress. The drugs gemcitabine and vinorelbine, followed by carmustine, etoposide and cyclophosphamide, and autologous stem cell transplantation are being studied to treat recurrent or refractory Hodgkin lymphoma.

Bortezomib is being studied in patients with high-risk Hodgkin lymphoma and other lymphomas for use prior to allogeneic stem cell transplantation.

Immunosuppressive drugs called "signal transduction inhibitors"—such as temsirolimus, tacrolimus and sirolimus—are under study to prevent graft-versus-host disease for patients who have undergone allogeneic stem cell transplantation.

Reduced-intensity allogeneic stem cell transplantation (nonmyeloablative allogeneic transplantation) clinical trials are under way to determine the usefulness of this approach in older and sicker patients for many blood cancers, including Hodgkin lymphoma. As a result, transplantation may be an option for patients aged 60 to 70 years. Patients being conditioned for a reduced-intensity transplant receive lower doses of chemotherapy drugs and/or radiation in preparation for the transplant. Immunosuppressive drugs are used to prevent rejection of the graft, and the engraftment of donor immune cells may allow these cells to attack the disease. The effectiveness of reduced-intensity transplantation is due to the graft-versus-lymphoma effect of the donor's lymphocytes rather than to high doses of chemotherapy.

See the free LLS publication *Blood and Marrow Stem Cell Transplantation* for comprehensive information about stem cell transplantation.

Vaccine Therapy. Scientists are developing vaccines that stimulate the immune system to combat and suppress lymphoma cell growth. Unlike classic vaccines, they do not prevent the disease but are used after first-line therapy to stimulate the immune system to attack any residual lymphoma cells. Vaccines have been used most extensively in trials studying follicular lymphoma, but Hodgkin lymphoma cells also present tumor antigens that could potentially enable a vaccine to work against them.

See the free LLS fact sheet *Vaccine Therapy Facts* for more information.

Social and Emotional Effects

A diagnosis of Hodgkin lymphoma is likely to bring a strong emotional response in patients, family members and friends. Although the disease is highly curable, people may react with anxiety, fear and depression. No one response is either universal or unexpected. Most people with Hodgkin lymphoma are able to cope with a diagnosis that is difficult to accept at first. With information and time, many people shift their focus to the therapy process ahead and the prospect of recovery. Over time, many survivors say they tend to worry less about "the little things" and place more importance on family, work and their relationships with other people.

Patients may initially want to focus on learning about Hodgkin lymphoma and its treatment. Patients and caregivers are advised to discuss the disease and its treatment, to ask questions and to convey fears or concerns to the patient's physicians, nurses, social workers and other members of the oncology team. These professionals are available to spend time with the patient, answer questions, lend emotional support and provide referrals to other useful resources.

During and after treatment, some patients may want to have friends, family members or caregivers help them obtain and process information from the physician and other members of the oncology team. The presence of another individual may help ease the patient's stress. This person can also help the patient ask questions and record and retain information. While it is not always possible to have this type of support, patients can reach out in other ways—for example, local or Internet support groups can provide a forum for discussion. Patients with Hodgkin lymphoma often

become acquainted with one another, and these friendships provide support. Some patients form supportive relationships with members of their healthcare team.

Treatment for Hodgkin lymphoma will mean changes in daily life, at least for a time. Treatment and its side effects, possible hospital stays, and concerns about recovery, finances, work or family life may cause a person to question his or her self-worth or identity. These issues may affect relationships, including intimate relationships. Recognition that these feelings are normal and knowing that many side effects are temporary may be reassuring. Open, honest communication regarding fears and concerns can be very helpful.

Finances. Treatment can be a financial strain for many individuals or families due to loss of income and the high cost of medications and procedures. LLS has a *Patient Financial Aid Program* that offers financial reimbursement for some medications, transportation and procedures for those in need. LLS also has a *Co-Pay Assistance Program* that offers assistance to patients toward private health insurance premiums, private insurance co-pay obligations, Medicare Part B, Medicare Plan D, Medicare Supplementary Health Insurance and Medicare Advantage premium or co-pay obligations. Prescription drugs covered under this program include those supplied to the patient by a pharmacy or administered in an office or hospital by a healthcare provider. Public or private prescription drug coverage is required to qualify for this program.

Depression. It is important to seek medical advice if a patient's mood does not improve over time—for example, if a patient is feeling depressed every day for a two-week period. Depression is an illness that should be treated even when a person is undergoing treatment for lymphoma. Treatment for depression has proven benefits for people living with cancer. There are many sources of help available to patients and caregivers. Aspects of care such as making treatment choices, finding the time and money for medical care and communicating with family members and friends can be stressful. Contact LLS or ask the healthcare team for guidance and referrals to other sources of help such as support groups, counseling services or community programs. The National Institute of Mental Health (NIMH) has several publications about depression that may be helpful. For more information go to www.nimh.nih.gov and enter "depression" in the search box at the top of the Web page or call NIMH at (866) 615-6464.

Children's Concerns. Most children who are diagnosed with Hodgkin lymphoma can look forward to a cure. They can expect to finish their educations, enter the workforce, marry and become parents. Still, each family that receives a diagnosis of childhood Hodgkin lymphoma is thrown into an unfamiliar world of treatment and follow-up care. The child, parents and siblings need support. Remember that help is available. Don't hesitate to ask for assistance for your child, yourself or other family members, even if you are already working with a psychologist, social worker or child life specialist. Many families will benefit from extra support.

Providing age-appropriate information to your child about the illness and treatment will help him or her build trust in both you and the treatment team and feel comfortable talking about fears and concerns. For practical guidance on how to support your child and other family members, deal with your own concerns, share the news with extended family and friends and make the transition to life after treatment ends, see the free LLS booklet *Coping With Childhood Leukemia and Lymphoma*. The free LLS booklets *Learning and Living with Cancer: Advocating for Your Child's Educational Needs*; *Pictures of My Journey: Activities for Kids With Cancer* and *The Stem Cell Transplant Coloring Book* may also be helpful.

We Can Help. LLS offers support programs through its national office and local chapters to help ease the emotional stresses that come with a blood cancer diagnosis. Visit www.LLS.org or contact the Information Resource Center at (800) 955-4572 to locate a chapter in your area, order free publications or speak to an Information Specialist.

Survivorship

Long-term and Late Effects of Treatment. Today much is understood about the specific types of treatment for Hodgkin lymphoma and the risk for long-term or late effects, including the risk of developing second cancers. The treatment of Hodgkin lymphoma has changed over the last several years and continues to evolve. Early-stage Hodgkin lymphoma patients are no longer exposed to prophylactic extended field radiation to reduce risk of recurrence. ABVD has been used extensively for more than 20 years, and it does not pose a significant risk for leukemia or infertility compared to prior therapies. However, there are not as much clear data on the long-term effects of chemotherapy as there are for the long-term effects of radiation, and further assessment is needed.

Patients who were treated 15 to 20 years ago did receive aggressive radiation therapy for stage I and II disease. This treatment is associated with long-term and late effects, including a risk for developing a second cancer. The degree of risk for developing a second cancer is related to both the extent and the dose of radiation treatment. Second cancers, including cancers of the breast, lung, stomach, bone and soft tissues, have been reported as soon as 5 years and as late as 30 years after radiation therapy.

Girls or women below the age of 30 who have radiation to the breast are at risk for developing breast cancer 15 to 20 years following radiation therapy for Hodgkin lymphoma. Male survivors of childhood cancers may also be at risk for developing second cancers. However, they do not appear to have the same risk for developing breast cancer as female childhood cancer survivors.

Radiation therapy can also injure the lungs, especially when given with bleomycin (the B in ABVD), and survivors who have had chest radiation also are at risk for developing lung cancer. People in this risk group should know that smoking further increases their risk. They should be advised not to start smoking or to stop smoking if they do smoke. There is strong scientific evidence that people who do not smoke but received chest radiation for Hodgkin lymphoma 10 to 20 years ago have a risk of lung cancer that is about four times that of the general population. Smokers who were treated for Hodgkin lymphoma with chest radiation may have as much as 25 to 40 times the increased risk of lung cancer, depending on whether they had radiation therapy alone or whether they also had chemotherapy.

Radiation therapy to the chest has also been linked to heart disease, including inflammation of the sac surrounding the heart (pericardium) or myocardial infarction (classic heart attack). Radiation therapy can injure the thyroid gland, causing decreased thyroid function (hypothyroidism).

In the 1970s and 1980s, combination chemotherapy consisting of mechlorethamine, Oncovin® (vincristine), procarbazine and prednisone (MOPP) was used to treat Hodgkin lymphoma. This treatment is associated with an increased risk of leukemia.

Fatigue is a common long-term effect for many people treated for cancer with chemotherapy, radiation therapy or combined modality therapy. For more information see the free LLS fact sheet *Fatigue*.

Follow-up Care. Survivors of Hodgkin lymphoma are advised to

- Keep a record of the treatments they received to help the physicians who monitor them for potential health problems after treatment ends.
- Get blood tests every 5 years to measure their cholesterol levels if they were treated with chest radiation.
- Have regular screening for heart disease.
- Have regular screening for cancer. Cancers of the breast, lung, stomach, bone and soft tissues have been reported as soon as 5 years after initial therapy.
- Practice breast self-examination, have early baseline mammograms (within 10 years after therapy or by age 25) and repeat mammograms every two to three years if female and treated with chest radiation for childhood or adult Hodgkin lymphoma. Although some women may develop breast cancer following treatment for Hodgkin lymphoma, it can be detected early and treated, providing the best chance for a cure.
- Have regular lung cancer screening if treated with chest radiation. Smoking further increases the risk of lung cancer and several other types of cancer including acute myelogenous leukemia and myelodysplastic syndromes.
- Have regular thyroid function check-ups.
- Seek medical and psychosocial support for fatigue, depression and other long-term effects if needed.

For additional information, including risks of specific chemotherapy agents, see the free LLS fact sheets *Long-term and Late Effects of Treatment in Adults* and *Long-term and Late Effects of Treatment for Childhood Leukemia or Lymphoma.*

Glossary

Absolute Neutrophil Count (ANC)
The number of neutrophils (a type of white cell) that a person has to fight infection. It is calculated by multiplying the total number of white blood cells by the percentage of neutrophils.

Albumin
A major protein in the blood that plays a role in fighting infections and building or repairing muscle tissue. The normal 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 lab uses to process the blood sample.

Allogeneic Stem Cell Transplantation
A treatment that uses donor stem cells to restore a patient's marrow and blood cells. First, the patient is given "conditioning therapy" (high-dose chemotherapy or high-dose chemotherapy with total body radiation) to treat the lymphoma and to "turn off" the patient's immune system so that the donor stems will not be rejected. A type of transplant called a "nonmyeloablative" transplant (or "mini" transplant) is under study. It uses lower doses of conditioning therapy and may be safer, especially for older patients. (For more information, see the free LLS booklet *Blood and Marrow Stem Cell Transplantation*.)

Anemia
A decrease in the number of red cells and, therefore, the hemoglobin concentration of the blood. The blood is less able to carry oxygen as a result. If severe, anemia can cause a pale complexion, weakness, fatigue and shortness of breath on exertion.

Antibodies
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 like bacteria and viruses or harmful toxins. Antibodies can also be made in the laboratory in two ways. If one injects material from one species into another, the latter will recognize it as foreign and make antibodies to it. These antibodies are usually polyclonal antibodies; that is, they react to multiple targets (antigens). A specific antibody known as a monoclonal antibody is produced through a special laboratory technique. Monoclonal antibodies react to only

one target (antigen) and can be used in several important ways. They can be used to identify and classify human leukemias and lymphomas or be altered so as to become useful in antibody-mediated immunotherapy.

Antigens
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 or allergens. Antigens stimulate plasma cells to produce antibodies.

Antioncogene See Tumor Suppressor Gene.

Apheresis
The process of removing components of a donor's blood and returning the unneeded parts to the donor. The process (also called "hemapheresis") uses continuous circulation of blood from a donor through an apparatus and then back to the donor. This process makes it possible to remove desired elements from large volumes of blood. Platelets, red cells, white cells and plasma can be removed separately. For example, this technique permits the harvest of enough platelets for transfusion from one donor (rather than six to eight separate donors). By this means, the recipient of the platelets is exposed to fewer donors or can be given HLA-matched platelets from a single related donor. This technique is also used to remove circulating blood stem cells, which can be frozen, stored and later used, instead of marrow stem cells, for transplantation.

Autologous Stem Cell Infusion
A technique, often referred to as "autologous stem cell transplantation," involving 1) harvesting the patient's stem cells from blood or marrow; 2) freezing them for later use; and 3) thawing and infusing them via an indwelling catheter after the patient has been given intensive chemotherapy or radiation therapy. The blood or marrow may be obtained from a patient with a disease of the marrow, such as acute myelogenous leukemia, when in remission or when the marrow and blood are not overtly abnormal (for example, in lymphoma). Technically, this procedure is not transplantation, which implies taking tissue from one person (donor) and giving it to another person (recipient). The purpose of this procedure is to restore blood cell production from the preserved and reinfused stem cells after intensive therapy has severely damaged the patient's remaining marrow. This procedure can be performed using marrow or blood stem cells. The latter can be harvested by hemapheresis. (For more information, see the free LLS booklet *Blood and Marrow Stem Cell Transplantation.*)

Biopsy
A procedure to obtain tissue for diagnosis. In many cases, a special needle can be used to obtain the tissue. In some cases, a larger piece of tissue may be surgically removed. Since the appearance of a lymph node is important in categorizing the type of lymphoma that may be present, surgical removal of an entire, swollen lymph node or nodes is necessary (lymph node biopsy). The tissue is placed in preservative, stained with dyes and examined under a microscope by a pathologist.

Bone Marrow
A spongy tissue in the hollow central cavity of the bones that is the site of blood cell formation. By 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 blood-forming marrow. In these sites the marrow is filled with fat cells. When marrow cells have matured into blood cells, they enter the blood that passes through the marrow and are carried throughout the body.

Bone Marrow Aspiration
A test to examine marrow cells to detect cell abnormalities. A marrow sample is usually taken from the patient's hip bone. After medication is given to numb the skin, the sample is removed using a special needle inserted through the bone into the marrow. The sample is looked at under a microscope for abnormal cells. The cells obtained can also be used for cytogenetic analysis and other tests.

Bone Marrow Biopsy
A test to examine marrow cells to detect cell abnormalities. This test differs from a bone marrow aspiration in that a small amount of bone filled with marrow is removed, usually from the hip bone. After medication is given to numb the area, a special biopsy needle is used to remove a core of bone containing marrow. The marrow is examined under a microscope to determine if abnormal cells are present. Bone marrow aspiration and biopsy may be done in the doctor's office or in a hospital. The two tests 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 Transplantation See Allogeneic Stem Cell Transplantation; Autologous Stem Cell Infusion.

Central Line (Indwelling Catheter)

A special tubing inserted into a large vein in the upper chest. The central line, sometimes referred to as an "indwelling catheter," is tunneled under the skin of the chest to keep it firmly in place. The external end of the catheter can be used to administer medications, fluids or blood products or to withdraw blood samples. With meticulous care, central lines can remain in place for long periods of time (many months) if necessary. They can be capped and remain in place in patients after they leave the hospital, and be used for outpatient chemotherapy or blood product administration. Several types of catheters (for example, Groshong®, Hickman®, and Broviac®) can be used for patients receiving intensive chemotherapy or nutritional support. A central line may be used for some Hodgkin lymphoma patients.

Chemotherapy

The use of chemicals (drugs or medications) to kill malignant cells. Numerous chemicals have been developed for this purpose, and most act to injure the DNA of the 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. Because the cells of the marrow, the intestinal tract, the skin and the hair follicles are most sensitive to these chemicals, injury to these organs causes the common side effects of chemotherapy; that is, mouth sores and hair loss.

Chromosomes

One of the 46 structures in all human cells made up principally of genes, which are specific stretches of DNA. "Genome" is the term for an organism's complete set of DNA. The human genome has been estimated to contain about 30,000 genes. The genes on the X and Y chromosomes—the sex chromosomes—are the determinants of our gender: two X chromosomes produce a female and an X and a Y chromosome produce a male. The number or size of chromosomes may be altered in lymphoma cells as a result of chromosome breakage and rearrangement (translocation).

Clonal

The designation for a population of cells derived from a single transformed parent cell. Virtually all cancers are derived from a single cell with an injury to its DNA (mutation) and thus are monoclonal. Leukemia, lymphoma and myeloma are examples of clonal cancers; that is, cancers derived from a single abnormal cell.

Colony-Stimulating Factor See Cytokines.

Combined Modality Therapy
Two or more types of treatment used alternately or at the same time to treat a patient's disease. For example, chemotherapy with involved field radiation therapy is a combined modality therapy for patients with Hodgkin lymphoma.

Computed Tomography (CT) Scan
A technique for imaging body tissues and organs. X-ray transmissions are converted to detailed images using a computer to synthesize 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 or abdomen permits detection of an enlarged lymph node, liver or spleen. A CT scan can be used to measure the size of these and other structures during and after treatment.

Cord Blood Stem Cells
Stem cells that are present in blood drained from the placenta and umbilical cord. These stem cells have the capability to repopulate the marrow of a compatible recipient and produce blood cells. Frozen cord blood is a source of donor stem cells for transplantation to HLA-matched recipients. Most cord blood transplants are given by matched or nearly matched unrelated donors.

CT Scan See Computed Tomography.

Cycle of Treatment
The designation for an intensive, clustered period of chemotherapy (and/or radiation therapy). The therapy may be given for several days or weeks, and this time period represents one cycle of treatment. The treatment plan may call for two, three or more cycles of treatment.

Cytogenetic Analysis
The process of analyzing the number and size of the chromosomes of cells. In addition to detecting chromosome alterations, 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 leukemia and lymphoma, in determining treatment approaches and in following the response to treatment. The individual who prepares and examines the chromosomes and interprets the results is called a "cytogeneticist."

Cytokines
Cell- (cyto-) derived chemicals that are secreted by various types of cells and act on other cells to stimulate or inhibit their function. Chemicals derived from lymphocytes are called "lymphokines." Chemicals derived from lymphocytes that act on other white cells are called "interleukins"; that is, they interact between two types of leukocytes. Some cytokines can be made commercially and used in treatment. Granulocyte-colony stimulating factor (G-CSF) and granulocyte-macrophage colony stimulating factor (GM-CSF) are two examples of such cytokines. They stimulate the production of neutrophils and shorten the period of low neutrophil counts in the blood after chemotherapy. Cytokines that stimulate cell growth are sometimes referred to as "growth factors."

Differentiation
The process by which stem cells give rise to functional cells of a single blood cell line. The differentiation of stem cells forms the red cells, platelets, neutrophils, monocytes, eosinophils, basophils and lymphocytes.

DNA
The genetic material in the cell. Deoxyribonucleic acid is the scientific name for DNA, which is made up of a sugar-phosphate backbone with ladderlike "steps" composed of purines and pyrimidines (building blocks of nucleic acids). The sequence of the purines and pyrimidines in the DNA is responsible for passing genetic information to new cells during the process of cell division, for passing genetic information from one generation to the next during reproduction and for providing the instructions for building proteins, which in turn carry out the major functions of a cell. A mutation is generally a change in or loss of the sequence of the purines or pyrimidines of the DNA. Mutations can lead to cell death, to changes in the way a cell functions or in some cases, to cancer.

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

Erythrocytes See Red Cells.

Fluorescent In Situ Hybridization (FISH)
A technique in which DNA probes tagged with fluorescent molecules emitting light of different wavelengths (and different colors) are used on tissue. The probes match to the chromosomes within the cells, and the chromosomes fluoresce in color. FISH is a means of studying the chromosomes in tissue.

G-CSF (Granulocyte-Colony Stimulating Factor) See Cytokines.

GM-CSF (Granulocyte-Macrophage Colony Stimulating Factor) See Cytokines.

Graft-Versus-Host Disease (GVHD)
The immune attack by lymphocytes in the donor's marrow or blood cell suspension (the graft) against the tissues of the recipient (the host). The immune cells most engaged in this reaction are donor T lymphocytes, which are present in the donor's blood or marrow, the source of stem cells. The principal sites of injury are the skin, the liver and the gastrointestinal tract. The reaction does not occur in identical twin transplants. The reaction may be minimal in closely matched individuals or severe in less well-matched individuals. These reactions are mediated in part by antigens that are not in the major HLA system and cannot be matched prior to transplant. For example, in the case of a female stem cell donor and a male recipient, factors that are produced by genes on the Y chromosome may be seen as foreign by the female donor's cells, which do not share the genes on the Y chromosome. This fact does not prohibit opposite-sex donors and recipients, but it makes the risk of immune reaction higher.

Granulocyte
A type of white cell that has a large number of granules in the cell body. Neutrophils, eosinophils and basophils are types of granulocytes.

Growth Factors See Cytokines.

Hemapheresis See Apheresis

Hematologist
A physician who specializes in the treatment of blood cell diseases. This person is either an internist who treats adults or a pediatrician who treats children.

Hematopathologist See Pathologist.

Hematopoiesis
The process of blood cell development in the marrow. The most undeveloped cells in the marrow are stem cells. They start the process of blood cell development. The stem cells begin to develop into young or immature blood cells such as red cells or white cells of various types. This process is called "differentiation." The young or immature blood cells then further develop into fully functional blood cells.

This process is called "maturation." The cells then leave the marrow and enter the blood and circulate throughout the body (see Figure 1, page 3.) Hematopoiesis is a continuous process that is active normally throughout life. The reason for this activity is that most blood cells live for short periods and must be continually replaced. Red cells die in four months, platelets in 10 days and most neutrophils in two or three days. About 500 billion blood cells are made each day. The constant demand for new blood cells explains the severe deficiency in blood cell counts when the marrow is invaded with cancer cells.

HLA

The abbreviation for "human leukocyte antigen." These proteins are on the surface of most tissue cells and give an individual his or her unique tissue type. HLA factors are inherited from mother and father, and the greatest likelihood of having the same HLA type is between siblings. On average, one in four siblings is expected to share the same HLA type. The testing for HLA factors is referred to as "tissue typing." There are six major groups of HLA: A, B, C, D, Dr, and Dq. These proteins on the surface of cells act as antigens when donated (transplanted) to another individual, the recipient. If the antigens on the donor cells are identical (for example, in identical twins) or very similar (for example, in HLA-matched siblings), the transplant (donated stem cells) is more likely to survive (engraft) in the recipient. In addition, the recipient's body cells are less likely to be attacked by the donated immune cells (a result called "graft-versus-host disease").

Immunophenotyping

A method that uses the reaction of antibodies with cell antigens to determine a specific type of cell in a sample of blood cells, marrow cells or lymph node cells. The antibodies react with specific antigens on the cell. A tag is attached to an antibody so that it can be detected. The tag can be identified by the laboratory equipment used for the test. As cells carrying their array of antigens are tagged with specific antibodies, they can be identified. Normal lymphocytes may be distinguished from Reed-Sternberg and Hodgkin cells.

Indwelling Catheter See Central Line.

Karyotype
The systematic arrangement, using images, of the 46 human chromosomes of a cell in 22 matched pairs (maternal and paternal member of each pair) by length from longest to shortest and other features. These 22 pairs are referred to as "autosomes." The sex chromosomes are shown as a separate pair (either XX or XY). (See Fluorescent In Situ Hybridization.)

Leukocytes See White Cells.

Leukopenia
A below-normal decrease in the concentration of blood leukocytes (white cells).

Lymphadenopathy
Enlargement of lymph nodes.

Lymphatic System
The system comprising the lymph nodes, the thymus gland (in the first several decades of life), the lymphatic channels, the lymphatic tissue of the marrow, the gastrointestinal tract, the skin and the spleen as well as the T, B and NK lymphocytes contained in these sites.

Lymph Nodes
Small structures, the size of beans, that contain large numbers of lymphocytes and are connected with each other by small channels called "lymphatics." These nodes are distributed throughout the body. In patients with lymphoma and some types of lymphocytic leukemia, the malignant lymphocytes grow and expand the lymph nodes so that they may become enlarged. This enlargement of lymph nodes can be seen, felt or measured by computed tomography (CT) scan or magnetic resonance imaging (MRI), depending on the degree of enlargement and the location.

Lymphocyte
A type of white cell that is the essential cell type in the body's immune system. There are three major types of lymphocytes: B lymphocytes, which produce antibodies to help combat infectious agents like bacteria, viruses and fungi; T lymphocytes, which have several functions, including assisting B lymphocytes to make antibodies; and natural killer cells, which can attack virus-infected cells or tumor cells.

Lymphokines See Cytokines.

Macrophage See Monocyte.

Magnetic Resonance Imaging (MRI)
A technique that provides detailed images of body structures. It differs from the CT scan in that the patient is not exposed to x-rays. Signals are generated in the tissues in response to a magnetic field that is produced by the MRI machine. These signals are then converted by the computer into images of body structures. Thus, the size, or a change in size, of tumor masses or of organs such as the lymph nodes, liver and spleen can be measured. This technique provides detailed images of body structures.

Marrow See Bone Marrow.

Minimal Residual Disease (MRD)
After treatment, blood and marrow may appear normal. "Minimal residual disease" (MRD) is the term used to describe the small amounts of cancer cells that may remain after treatment, which may be identified only by sensitive molecular techniques or imaging.

Monoclonal See Clonal.

Monocyte
A type of white cell that represents about 5 to 10 percent of the cells in normal human blood. The monocyte and the neutrophil are the two major microbe-eating and -killing cells in the blood. When monocytes leave the blood and enter the tissue, they are converted to *macrophages.* The macrophage is the monocyte in action, and 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.

MRI See Magnetic Resonance Imaging.

Multidrug Resistance (MDR)

A characteristic of cells that makes them resistant to the effects of several different classes of drugs. There are several forms of drug resistance. They are each determined by genes that govern how the cell will respond to the chemical agents. One type of multidrug resistance (MDR) involves the ability to force several drugs out of cells. The outer wall, or membrane, of the cell contains a pump that ejects chemicals, preventing them from reaching a toxic concentration. The resistance to drugs can be traced to the expression of genes that direct the formation of high amounts of the protein that prevents the drugs from having their effects on the malignant cells. If the gene or genes involved are not expressed or are weakly expressed, the cells are more sensitive to the drug's effect. If the genes are highly expressed, the cells are less sensitive to the drug's effect.

Mutation

An alteration in a gene that results from a change to a part of the stretch of DNA that represents the gene. A "germ cell mutation" is present in the egg or the sperm and can be transmitted from parent(s) to offspring. A "somatic cell mutation" occurs in a specific tissue cell and can result in the growth of that specific tissue cell into a tumor. Most cancers start after a somatic mutation. In leukemia, lymphoma or myeloma, a primitive marrow or lymph node cell undergoes a somatic mutation (or mutations) that leads to the formation of a tumor. Cases of leukemia, lymphoma or myeloma are caused by a somatic mutation in a primitive marrow (blood-forming) or lymphatic system cell. If the mutation results from a major abnormality of chromosomes such as a translocation, it can be detected by cytogenetic examination. Sometimes the alteration in the gene is more subtle and requires more sensitive tests to identify the oncogene (mutated gene).

Neutropenia

A decrease below normal in the concentration of neutrophils, a type of white cell.

Neutrophil

The principal phagocyte (microbe-eating cell) in the blood. This blood cell is the main cell that combats infections. Often, it is not present in sufficient quantities after chemotherapy. A severe deficiency of neutrophils increases the patient's susceptibility to infection. A neutrophil may be called a "poly" (polymorphonuclear neutrophil) or "seg" (segmented neutrophil) because its nucleus has several lobes.

Oncogene
A mutated gene that is the cause of a cancer. Several subtypes of acute myelogenous leukemia, acute lymphocytic leukemia and lymphoma, and nearly all cases of chronic myelogenous leukemia, are each associated with an oncogene.

Oncologist
A physician who diagnoses and treats patients with cancer. Oncologists are usually internists who treat adults or pediatricians who treat children. Radiation oncologists specialize in the use of radiation to treat cancer, and surgical oncologists specialize in the use of surgical procedures to diagnose and treat cancer. These physicians cooperate and collaborate to provide the best treatment plan (surgery, radiation therapy, chemotherapy or immunotherapy) for the patient.

Opportunistic Infections
Unusual infections to which patients treated for cancer may be susceptible because of the suppression of their immune system. "Opportunistic" is the term used to describe infections with bacteria, viruses, fungi or protozoa to which individuals with a normal immune system are not susceptible. These organisms take advantage of the opportunity provided by immunodeficiency, especially when coupled with very low white cell counts resulting from therapy or the disease itself.

Pancytopenia
A decrease below normal in the concentration of the three major blood cell types: red cells, white cells and platelets.

Pathologist
A physician who identifies disease by studying tissues under a microscope. A *hematopathologist* is a pathologist who studies diseases of blood cells by looking at peripheral blood smears, bone marrow aspirates and biopsies, lymph nodes and other tissues, using his or her expertise to identify diseases such as Hodgkin lymphoma. In addition to the microscope, a hematopathologist also uses laboratory values, flow cytometry and molecular diagnostic tests to make the most accurate diagnosis. The hematopathologist works closely with the hematologist/oncologist who sees the patient and decides on the best treatment based upon the diagnosis.

Percutaneously Inserted Central Venous Catheter (PICC or PIC Line)

A type of catheter inserted through a vein in the arm. Some drugs used to treat Hodgkin lymphoma are given by mouth, such as prednisone. Many other drugs are administered intravenously (IV), and PICCs can be used to give these medications. PICCs can also be used to give nutrition and blood cells, if needed, and to take blood samples.

Phagocytes

Cells that readily eat (ingest) microorganisms such as bacteria and fungi and can kill them as a means of protecting the body against infection. The two principal phagocytes are neutrophils and monocytes. They leave the blood and enter tissues in which an infection has developed. A severe decrease in the number of these cells circulating in the blood is the principal cause of susceptibility to infection in patients treated with intensive radiotherapy and/or chemotherapy. Treatment may suppress blood cell production in the marrow, resulting in deficiencies of these phagocytic cells. (See Opportunistic Infections.)

Platelets

Small cell fragments (about one-tenth the volume of red cells) that stick to the site of blood vessel injury, aggregate and seal off the injured blood vessel to stop bleeding. “Thrombocyte” is a synonym for platelet and is often used as the prefix in terms describing disorders of platelets, such as thrombocytopenia (too few) or thrombocythemia (too many).

Platelet Transfusion

The transfusion of donor platelets to support patients treated for Hodgkin lymphoma. The platelets can be pooled from several unrelated donors and given as pooled, random-donor platelets. The platelets from about 6 one-unit blood donors are required to significantly raise the platelet count in a recipient. Sufficient platelets can be obtained from one donor by a procedure known as “apheresis.” This technique skims the platelets from large volumes of blood passing through the apheresis machine. The red cells and plasma are returned to the donor. The advantage of single-donor platelets is that the patient is not exposed to the different antigens on platelets from many different people and is less likely to develop antibodies against donor platelets. HLA-matched platelet transfusion can be given from a related donor with an identical or very similar HLA tissue type.

Polymerase Chain Reaction (PCR)

A technique to expand trace amounts of DNA or RNA so that the specific type of the DNA or RNA can be studied or determined. This technique has become useful in detecting a very low concentration of residual leukemia or lymphoma cells, too few to be seen using a microscope. PCR can detect the presence of one leukemic cell among 500,000 to one million nonleukemic cells. PCR requires a specific DNA (or RNA) abnormality or marker, like an oncogene, in the leukemic or lymphomatous cells in order to be used for identifying residual abnormal cells.

Port

A small device used with a central line (catheter) to access a vein. The port is placed under the skin of the chest. After the site heals, no dressings or any special home care is needed. To give medicines or nutrition, or to take blood samples, the doctor or nurse puts a needle through the skin into the port. A numbing cream can be put on the skin before the port is used. A port may be used for some patients with Hodgkin lymphoma.

Positron Emission Tomography (PET) Scan

An imaging technique for locating lymphoma masses. PET is sometimes combined with a CT scan to establish the precise location of lymphoma masses. PET is highly specific for detecting very small lymphoma masses compared to other imaging procedures. FDG-positron emission tomography scans (FDG-PET) measure altered tissue activity by using FDG ([18F] fluorodeoxyglucose, a radioactive substance). FDG is given to the patient by IV (intravenously). Lymphoma cells trap more FDG than normal cells and the FDG concentration is measured in the cells. FDG-PET is an effective tool for detecting primary lymphoma and recurrent disease. This technique helps to differentiate between scar tissue and lymphoma masses. It can provide a sensitive and relatively rapid assessment of a patient's response to therapy and may also be used for staging.

Radiation Therapy (Radiotherapy)

The use of x-rays and other forms of radiation in treatment. Radiotherapy is useful in the treatment of localized lymphomas, especially Hodgkin lymphoma, central nervous system lymphoblastic leukemia, and localized myeloma.

Radioactive Isotope
A form of a molecule that emits radiation. Certain types of radiation can damage cancer cells. Physicians use radioactive isotopes to treat cancer in several ways, including attaching the isotope to antibodies. The antibodies can attach to the cancer cell and the radiation can destroy it.

Recurrence or Relapse
The return of a disease after it has been in remission following treatment.

Red Cells
Blood cells (erythrocytes) that carry hemoglobin, which binds oxygen and carries it to the tissues of the body. The red cells make up about 40 to 45 percent of the volume of the blood in healthy individuals.

Remission
A disappearance of evidence of a disease, usually as a result of treatment. The terms "complete" and "partial" are used to modify the term "remission." Complete remission means that all evidence of the disease is gone. Partial remission means that the disease is markedly improved by treatment, but residual evidence of the disease is present. Long-term benefit usually requires a complete remission, especially in acute leukemia or progressive lymphomas.

Resistance to Treatment
The ability of cells to grow despite their exposure to medicine that would ordinarily kill them. Refractory leukemia is the condition in which a proportion of malignant cells resist the damaging effects of a drug or drugs. Cells have several ways to develop drug resistance. (See Multidrug Resistance.)

Spleen
An organ located in the left upper portion of the abdomen just under the left side of the diaphragm. It contains clusters of lymphocytes and also filters old or worn-out cells from the blood. It is often affected in lymphocytic leukemias and lymphomas. Enlargement of the spleen is called "splenomegaly." Removal of the spleen by surgery is known as "splenectomy." Removal of the spleen is used to treat certain diseases. Most of the functions of the spleen can be performed by other organs, such as the lymph nodes and liver, but a person whose spleen has been removed is at higher risk for infection. He or she is given antibiotic therapy immediately at the first sign of infection, such as a fever.

Stem Cells
Primitive cells in marrow that develop into the red cells, white cells and platelets. Stem cells are found chiefly in the marrow, but some leave the marrow and circulate in the blood. Using special techniques, the stem cells in blood can be collected, preserved by freezing and later thawed and used for stem cell therapy. (See Hematopoiesis.)

Thrombocytopenia
A decrease below normal in the number of the circulating platelets.

Toxin
A naturally derived substance that is a poison for cells. A toxin can be attached to antibodies that attach to cancer cells. The toxin may kill the cancer cells.

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

Tumor Suppressor Gene
A gene that acts to prevent cell growth. If a mutation occurs in this gene that "turns off" the gene and causes loss of function, it may make the individual more susceptible to the development of cancer in the tissue in which the mutation occurred. Another term for tumor suppressor gene is "antioncogene."

White Cells
Leukocytes. There are five major types of white cells in the blood: neutrophils, eosinophils, basophils, monocytes and lymphocytes.

Resources

Nontechnical Resources

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Visit the "Select Reading List" at www.LLS.org to see suggested books on a wide range of topics.

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