



Osteosarcoma

What is cancer?

The body is made up of trillions of living cells. Normal body cells grow, divide, and die in an orderly fashion. During the early years of a person's life, normal cells divide faster to allow the person to grow. After the person becomes an adult, most cells divide only to replace worn-out or dying cells or to repair injuries.

Cancer begins when cells in a part of the body start to grow out of control. There are many kinds of cancer, but they all start because of out-of-control growth of abnormal cells.

Cancer cell growth is different from normal cell growth. Instead of dying, cancer cells continue to grow and form new, abnormal cells. Cancer cells can also invade (grow into) other tissues, something that normal cells cannot do. Growing out of control and invading other tissues are what makes a cell a cancer cell.

Cells become cancer cells because of damage to DNA. DNA is in every cell and directs all its actions. In a normal cell, when DNA gets damaged the cell either repairs the damage or the cell dies. In cancer cells, the damaged DNA is not repaired, but the cell doesn't die like it should. Instead, this cell goes on making new cells that the body does not need. These new cells will all have the same damaged DNA as the first cell does.

People can inherit damaged DNA, but most DNA damage is caused by mistakes that happen while the normal cell is reproducing or by something in our environment. Sometimes the cause of the DNA damage is something obvious, like cigarette smoking. But often no clear cause is found.

In most cases the cancer cells form a tumor. Some cancers, like leukemia, rarely form tumors. Instead, these cancer cells involve the blood and blood-forming organs and circulate through other tissues where they grow.

Cancer cells often travel to other parts of the body, where they begin to grow and form new tumors that replace normal tissue. This process is called metastasis. It happens when the cancer cells get into the bloodstream or lymph vessels of our body.

No matter where a cancer may spread, it is always named for the place where it started. For example, breast cancer that has spread to the liver is still called breast cancer, not liver cancer. Likewise, prostate cancer that has spread to the bone is metastatic prostate cancer, not bone cancer.

Different types of cancer can behave very differently. For example, lung cancer and breast cancer are very different diseases. They grow at different rates and respond to different treatments. That is why people with cancer need treatment that is aimed at their particular kind of cancer.

Not all tumors are cancerous. Tumors that aren't cancer are called benign. Benign tumors can cause problems – they can grow very large and press on healthy organs and tissues – but they cannot grow into (invade) other tissues. Because they can't invade, they also can't spread to other parts of the body (metastasize). These tumors are almost never life threatening.

What are the differences between cancers in adults and children?

The types of cancers that develop in children are different from the types that develop in adults. Although there are exceptions, childhood cancers tend to respond better to chemotherapy. Children's bodies also tend to tolerate chemotherapy better than adults' bodies do. But, because chemotherapy can have some long-term side effects, children who survive their cancer need careful attention for the rest of their lives.

Since the 1960s, most children and adolescents with cancer have been treated at specialized centers designed for them. These centers offer children the advantage of being treated by a team of specialists who know the differences between adult and childhood cancers, as well as the unique needs of children with cancers. This team usually includes pediatric oncologists, pathologists, surgeons, radiation oncologists, pediatric oncology nurses, and nurse practitioners.

These centers also have psychologists, social workers, child life specialists, nutritionists, rehabilitation and physical therapists, and educators who can support and educate the entire family.

Most children with cancer in the United States are treated at a center that is a member of the Children's Oncology Group (COG). All of these centers are associated with a university or children's hospital. As we have learned more about treating childhood cancer, it has become even more important that treatment be given by experienced experts.

What is osteosarcoma?

Osteosarcoma (also called *osteogenic sarcoma*) is a type of cancer that starts in the bones. To understand osteosarcoma, it helps to know something about the normal structure and function of bones.

About normal bones

Many people may think of bones as just being part of the skeleton, like the steel girders that support a building. But bones actually have a number of different functions.

- Some bones help support and protect our vital organs. Examples include the skull bones, breast bone (sternum), and ribs. These types of bones are often referred to as *flat bones*.
- Other bones, such as those in the arms and legs, make a framework for our muscles that helps us move. These are called *long bones*.
- Bones also make new blood cells. This is done in the soft, inner part of some bones called the *bone marrow*, which contains blood-forming cells. New red blood cells, white blood cells, and platelets are made in bone marrow.
- Bones also provide the body with a place to store minerals such as calcium.

Because bones are very hard and don't change shape – at least once we reach adulthood – we may think of bones as being dead, but they are complex, living tissues. Like all other tissues of the body, bones have many kinds of living cells. Two main types of cells in our bones help them stay strong and keep their shape.

- *Osteoblasts* help build up bones by forming the bone matrix (the connective tissue and minerals that give bone its strength).
- *Osteoclasts* break down bone matrix to prevent too much of it from building up, and they help bones keep their proper shape. By depositing or removing minerals from the bones, osteoclasts also help control the amount of these minerals in the blood.

Osteosarcoma

Osteosarcoma is the most common type of cancer that develops in bone. Like osteoblasts of normal bone, the cells that form this cancer make bone matrix. But the bone matrix of an osteosarcoma is not as strong as that of normal bones.

Most osteosarcomas occur in children and young adults. Teenagers are the most commonly affected age group, but osteosarcoma can occur at any age.

In children and young adults, osteosarcoma usually develops in areas where the bone is growing quickly, such as near the ends of the long bones. Most tumors develop in the bones around the knee, either in the distal femur (the lower part of the thigh bone) or the proximal tibia (the upper part of the shinbone). The proximal humerus (the part of the

upper arm bone close to the shoulder) is the next most common site. However, osteosarcoma can develop in any bone, including the bones of the pelvis (hips), shoulder, and jaw. This is especially true in older adults.

Subtypes of osteosarcoma

Several subtypes of osteosarcoma can be identified by how they look on x-rays and under the microscope. Some of these subtypes have a better prognosis (outlook) than others.

Based on how they look under the microscope, osteosarcomas can be classified as high grade, intermediate grade, or low grade.

High-grade osteosarcomas: These are the fastest growing types of osteosarcoma. When seen under a microscope, they do not look like normal bone and have many cells in the process of dividing. Most osteosarcomas that occur in children and teens are high grade. There are several types of high-grade osteosarcomas.

- Osteoblastic
- Chondroblastic
- Fibroblastic
- Mixed
- Small cell
- Telangiectatic
- High-grade surface (juxtacortical high grade)

Other high-grade osteosarcomas include:

- Pagetoid: a tumor that develops in someone with Paget disease of the bone
- Extra-skeletal: a tumor that starts in a part of the body other than a bone
- Post-radiation: a tumor that starts in a bone that had once received radiation therapy

Intermediate-grade osteosarcomas: These uncommon tumors fall in between high-grade and low-grade osteosarcomas. (They are treated as if they are low-grade osteosarcomas.)

- Periosteal (juxtacortical intermediate grade)

Low-grade osteosarcomas: These are the slowest growing osteosarcomas. The tumors look more like normal bone and have few dividing cells when seen under a microscope.

- Parosteal (juxtacortical low grade)
- Intramedullary or intraosseous well differentiated (low-grade central)

The grade of the tumor tells doctors how likely it is that the cancer will grow and spread to other parts of the body. The grade plays a role in determining the stage of the tumor and the

type of treatment used. For more on staging, see the section, "How is osteosarcoma staged?"

Other types of bone tumors

Several other types of tumors can start in the bones.

Malignant (cancerous) bone tumors

Ewing tumors are the second most common malignant bone tumor in children. They are described in the American Cancer Society document, *Ewing Family of Tumors*.

Most other types of bone cancers are usually found in adults and are rare in children. These include chondrosarcoma (cancer that develops from cartilage), malignant fibrous histiocytoma, fibrosarcoma, chordoma, and malignant giant cell tumor of bone. For more information on these cancers, see the American Cancer Society document, *Bone Cancer*.

Many types of cancer that start in other organs of the body can spread to the bones. These are sometimes referred to as *metastatic bone cancers*, but they are not true bone cancers. For example, prostate cancer that spreads to the bones is still prostate cancer and is treated like prostate cancer. For more information, see the document, *Bone Metastasis*.

Benign (non-cancerous) bone tumors

Not all bone tumors are malignant. Cells that form benign tumors do not spread to other parts of the body. They are usually not life threatening and can often be cured by surgery. There are many types of benign bone tumors.

- Osteomas are benign tumors formed by bone cells.
- Chondromas are benign tumors formed by cartilage cells.
- Osteochondromas are benign tumors with both bone and cartilage cells.

Other benign bone tumors include eosinophilic granuloma of bone, non-ossifying fibroma, enchondroma, xanthoma, giant cell tumor, and lymphangioma.

The rest of this document refers only to osteosarcoma.

What are the key statistics about osteosarcoma?

Osteosarcoma is not a common cancer. Each year, about 800 new cases of osteosarcoma are diagnosed in the United States. About 400 of these are in children and teens.

Most osteosarcomas occur in children and young adults between the ages of 10 and 30. Teenagers are the most commonly affected age group, but osteosarcoma can occur at any age. About 10% of all osteosarcomas occur in people over the age of 60.

Osteosarcomas account for about 3% of childhood cancers, but they make up a much smaller percentage of adult cancers.

What are the risk factors for osteosarcoma?

A risk factor is anything that affects your chance of getting a disease such as cancer. Lifestyle-related risk factors are important in many cancers in adults. Examples of lifestyle-related risks include obesity, unhealthy diets, not getting enough exercise, smoking, and drinking too much alcohol. But unlike many adult cancers, lifestyle-related risk factors do not seem to play a large role in childhood cancers, including childhood osteosarcomas. So far, lifestyle-related factors have not been linked to osteosarcomas in adults, either.

Age

The risk of osteosarcoma is highest during the teenage "growth spurt." This suggests there may be a link between rapid bone growth and risk of tumor formation. The risk goes down in young adults, but rises again in older adults (usually over the age of 60). Osteosarcoma in older adults is often linked to another cause, such as a long-standing bone disease.

Height

Children with osteosarcoma usually are tall for their age. This is another indication that osteosarcoma may be related to rapid bone growth.

Gender

Osteosarcoma is more common in males than in females. Females tend to develop it at a slightly earlier age, possibly because they tend to have their growth spurts earlier.

Race/ethnicity

Osteosarcoma is slightly more common in African Americans than in whites.

Radiation to bones

People who were treated with radiation therapy for another cancer may have a higher risk of later developing osteosarcoma. Being treated at a younger age and being treated with higher doses of radiation both increase the risk of developing osteosarcoma.

It is not clear if imaging tests that use radiation, such as x-rays, CT scans, and bone scans, raise the risk of developing osteosarcoma. The amount of radiation used for these tests is many times lower than that used for radiation therapy. If there is any increased risk it is likely to be very small, but doctors try to limit the use of these types of tests in children whenever possible, just in case.

Certain bone diseases

People with certain non-cancerous bone diseases have an increased risk of developing osteosarcoma.

Paget disease of the bone: This is a condition that causes abnormal bone tissue to form in one or more bones. It mostly affects people older than 50. Affected bones are heavy and thick but are weaker than normal bones and are more likely to break. Usually this condition by itself is not life-threatening. But bone sarcomas (mostly osteosarcoma) develop in about 1% of people with Paget disease, usually when many bones are affected.

Multiple hereditary osteochondromas: Osteochondromas are benign bone tumors formed by bone and cartilage. Each osteochondroma has a very slight risk of developing into an osteosarcoma. Most osteochondromas are cured by surgery. However, some people inherit a tendency to develop many osteochondromas, and it may not be possible to remove them all. The more osteochondromas a person has, the greater the risk of developing osteosarcoma.

Inherited cancer syndromes

Children with certain rare, inherited cancer syndromes have an increased risk of developing osteosarcoma.

- Retinoblastoma is a rare eye cancer of children that can be hereditary. The inherited form of retinoblastoma is caused by a mutation (abnormal copy) of the *RBI* gene. Those with this mutation also have an increased risk of developing bone or soft tissue sarcomas, including osteosarcoma. If radiation therapy is used to treat the retinoblastoma, the risk of osteosarcoma in the bones around the eye is even higher.
- The Li-Fraumeni syndrome makes people much more likely to develop several types of cancer, including breast cancer, brain cancer, osteosarcoma, and other types of sarcoma. Most of those cases are caused by a mutation of the *TP53* tumor suppressor gene.
- Another syndrome that includes bone cancer is the Rothmund-Thompson syndrome. Children with this syndrome are short and tend to have skeletal problems and rashes. They also are more likely to develop osteosarcoma. This syndrome is caused by abnormal changes in the *REQLA* gene.
- Other rare inherited conditions, including Bloom syndrome and Werner syndrome, have also been linked to an increased risk of osteosarcoma.

The way in which inherited DNA changes make certain people more likely to develop osteosarcoma is explained in the section, “Do we know what causes osteosarcoma?”

Do we know what causes osteosarcoma?

We do not know what causes most osteosarcomas. Scientists have found that osteosarcoma is linked with a number of other conditions, which were described in "What are the risk factors for osteosarcoma?". But in most patients with osteosarcoma, the cause of their cancer is not clear at this time.

Over the past few years, scientists have made great progress in understanding how certain changes in our DNA can cause cells to become cancerous. DNA is the chemical in each of our cells that makes up our genes – it carries the instructions for nearly everything our cells do. We usually look like our parents because they are the source of our DNA. However, DNA affects more than how we look. It influences our risks for developing certain diseases, including some kinds of cancer.

Some genes (parts of our DNA) contain instructions for controlling when our cells grow and divide. Genes that speed up cell growth and division are called *oncogenes*. Others that slow down cell division or cause cells to die at the right time are called *tumor suppressor genes*. Cancers can be caused by DNA changes that turn on oncogenes or turn off tumor suppressor genes.

Some people inherit DNA mutations (changes) from a parent that increase their risk of cancer. In this situation, all of the cells in the body carry the same mutation. These are called *germline* or *inherited* mutations. Usually, however, cancer-causing mutations are acquired during life rather than inherited before birth. In this case, the mutation occurs only in the cells that will develop the cancer. These are called *somatic* or *acquired* mutations.

Inherited DNA changes

We know the DNA mutations that cause some inherited forms of osteosarcoma. For example:

The Li-Fraumeni syndrome is usually caused by inherited mutations that turn off the *TP53* tumor suppressor gene. These mutations give a person a very high risk of developing one or more types of cancer that include breast cancer, brain cancer, osteosarcoma, and other cancers.

Inherited defects of the retinoblastoma (*RBI*) tumor suppressor gene increase the risk of developing retinoblastoma, a type of eye cancer that affects children. Children with this defect also have an increased risk for developing osteosarcoma.

Acquired DNA mutations

Most osteosarcomas are not caused by inherited DNA mutations. They are the result of mutations acquired during the person's lifetime. These mutations are present only in the cancer cells and are not passed on to children.

Although radiation therapy is very useful in treating some forms of cancer, it can also cause cancer by damaging DNA. This is why bones exposed to radiation used to treat another cancer are more likely to develop osteosarcoma in the treated site later in the person's lifetime.

Other DNA mutations have no apparent cause but may result from random errors that occur when cells reproduce. Scientists do not know exactly why these mutations happen to some people but not to others. Before a cell divides, it must copy its DNA so that both new cells have the same set of instructions. Sometimes this copying process is not completely accurate. Cells that are dividing quickly are more likely to create new "daughter cells" with mistakes in their DNA, which increases the risk that a cancer (such as osteosarcoma) may develop. This may be why some normal situations (such as the teenage growth spurt) and diseases (such as Paget disease of bone) that cause rapid bone growth increase the risk of developing osteosarcoma.

Other than radiation, there are no known lifestyle-related or environmental causes of osteosarcoma, so it is important to remember that there is nothing these people could have done to prevent these cancers.

Researchers now understand some of the gene changes that may occur in osteosarcomas, but it's still not clear what might cause these changes. As we learn more about what causes osteosarcoma, hopefully we will be able to use this knowledge to develop ways to better prevent and treat it.

Can osteosarcoma be prevented?

Although the risk of many adult cancers can be reduced with certain lifestyle changes (such as maintaining a healthy weight or quitting smoking), at this time there are no known ways to prevent osteosarcoma.

Most known risk factors for osteosarcoma (age, height, race, gender, and certain bone diseases and inherited conditions) cannot be changed. Other than radiation therapy, there are no known lifestyle-related or environmental causes of osteosarcoma, so at this time there is no way to protect against most of these cancers.

Can osteosarcoma be found early?

At this time, there are no widely recommended screening tests for this cancer. (Screening is testing for cancer in people without any symptoms.)

Still, most cases of osteosarcoma are found at an early stage, before they have clearly spread to other parts of the body. Symptoms such as bone pain or swelling often prompt a

person (or a child's parents) to go to a doctor. (For more on possible signs and symptoms of osteosarcoma, see the section "How is osteosarcoma diagnosed?")

People with certain bone diseases and families known to carry inherited conditions that raise the risk of this cancer (listed in "What are the risk factors for osteosarcoma?") should talk with their doctors about the possible need for increased monitoring for this disease. This type of cancer usually does not run in families, but looking out for the early signs of cancer is important in treating it successfully.

How is osteosarcoma diagnosed?

Osteosarcomas are usually found when a person reports signs or symptoms they have noticed to their doctor. If a tumor is suspected, tests will be needed to confirm the diagnosis.

Signs and symptoms of osteosarcoma

Pain and swelling

Pain in the affected bone (usually around the knee or in the upper arm) is the most common symptom in patients with osteosarcoma. At first, the pain might not be constant and may be worse at night. The pain often increases with activity and may result in a limp if the tumor is in a leg.

Swelling in the area is the next most common symptom, although it may not occur until several weeks after the pain starts. Depending on where the tumor is, it may be possible to feel a lump or mass.

Unfortunately, limb pain and/or swelling are very common in normal, active children and teenagers, and might not prompt a doctor visit right away. This can delay a diagnosis. These symptoms are less common in adults and should be a sign to see a doctor as soon as possible.

Bone fractures (breaks)

Although osteosarcoma may weaken the bone it develops in, the bones often do not break. Telangiectatic osteosarcomas, which are rare, tend to weaken bones more than other forms of osteosarcoma and are more likely to cause a fracture at the tumor site.

People with a fracture next to or through an osteosarcoma often describe a limb that was sore for a few months and suddenly became very painful when the fracture occurred.

Medical history and physical exam

If there are signs or symptoms that suggest a tumor, the doctor will want to take a complete medical history to find out more about the symptoms. A physical exam can

provide information about the tumor and other health problems. For example, the doctor may be able to see or feel an abnormal mass.

If the doctor suspects a person may have an osteosarcoma (or other tumor), more tests will probably be done. These might include imaging tests, biopsies, and/or lab tests.

Imaging tests

Imaging tests use x-rays, magnetic fields, or radioactive substances to create pictures of the inside of the body. Imaging tests may be done for a number of reasons, including:

- To help find out if a suspicious area might be cancer
- To learn how far cancer may have spread
- To help determine if treatment has been effective
- To look for signs that the cancer may have come back

Most patients who have or may have cancer will have one or more of these tests.

Bone x-ray

Doctors can often recognize or at least suspect osteosarcoma on plain x-rays of the bone. But other imaging tests may be needed as well.

Even if results of an x-ray strongly suggest an osteosarcoma, a biopsy will still be needed to confirm that it is cancer rather than some other problem, such as an infection.

Magnetic resonance imaging (MRI) scan

MRI scans provide detailed images of soft tissues in the body. But MRI scans use radio waves and strong magnets instead of x-rays, so no radiation is involved. The energy from the radio waves is absorbed by the body and then released in a pattern formed by the type of body tissue and by certain diseases. A computer translates the pattern into a very detailed image of parts of the body. A contrast material called gadolinium may be injected into a vein before the scan to better see details.

Often, an MRI scan is done to better define a bone mass seen on an x-ray. MRI scans can usually tell if the mass is likely to be a tumor, an infection, or some type of bone damage from other causes. MRI scans can also help determine the exact extent of a tumor, as they provide a detailed view of the marrow inside bones and the soft tissues around the tumor. Sometimes, the MRI can help find small bone tumors several inches away from the main tumor (called *skip metastases*). Defining the extent of the tumor is very important when planning surgery. An MRI scan usually gives better details than a CT scan (described below).

Having an MRI scan may take up to an hour. You (or your child) may have to lie on a table that slides inside a narrow tube, which is confining and can be distressing. The newer, more open MRI machines can help with these feelings, but the test still requires

staying still for long periods of time. The machines also make buzzing and clicking noises that may be disturbing. Sometimes, younger children are given medicine to help keep them calm or even sleep during the test.

Computed tomography (CT) scan

The CT scan is an x-ray test that produces detailed cross-sectional images of parts of the body. Instead of taking one picture, like a regular x-ray, a CT scanner takes many pictures as it rotates around a person lying on a table. A computer then combines these pictures into images of slices of the part of the body being studied. Unlike a regular x-ray, a CT scan creates detailed images of the soft tissues in the body.

Before the scan, you (or your child) may be asked to drink a contrast solution and/or get an intravenous (IV) injection of a contrast dye that helps better outline abnormal areas in the body. If the contrast dye is to be injected, you (or your child) may need an IV line. The contrast may cause some flushing (a feeling of warmth, especially in the face). Some people are allergic and get hives. Rarely, more serious reactions like trouble breathing or low blood pressure can occur. Be sure to tell the doctor if you (or your child) have any allergies or have ever had a reaction to any contrast material used for x-rays.

CT scans take longer than regular x-rays, but not as long as MRI scans. You (or your child) will need to lie still on a table while they are being done. During the test, the table slides in and out of the scanner, a ring-shaped machine that completely surrounds the table. Some people feel a bit confined by the ring they have to lie in while the pictures are being taken. In some cases, children may need to be sedated before the test to stay still and help make sure the pictures come out well.

Spiral CT (also known as *helical CT*) is now used in many medical centers. This type of CT scan uses a faster machine that lowers the dose of radiation used during the test and gives more detailed pictures.

CT scans are sometimes used to look at the affected bone to see if the tumor has grown into nearby muscle, fat, or tendons, although MRI is often better for this. A CT scan of the chest is often done to look for spread of the cancer to the lungs.

Chest x-ray

This test is sometimes done to look for spread of the cancer to the lungs. It can find larger tumors, but it is not as good as a CT scan for spotting smaller tumors. If a CT scan of the chest is done, a chest x-ray may not be needed.

Bone scan

A bone scan can help show if a cancer has spread to other bones, and is often part of the workup for people with osteosarcoma. This test is useful because it provides a picture of the entire skeleton at once.

For this test, a small amount of low-level radioactive material is injected into a vein (intravenously, or IV). The substance settles in areas of damaged bone throughout the entire skeleton over the course of a couple of hours. You (or your child) then lie on a table for about 30 minutes while a special camera detects the radioactivity and creates a picture of the skeleton. Younger children may be given medicine to help keep them calm or even asleep during the test.

Areas of active bone changes appear as "hot spots" on the skeleton because they attract the radioactivity. These areas may suggest the presence of cancer, but other bone diseases can also cause the same pattern. To make an accurate diagnosis, other imaging tests such as plain x-rays, or MRI scans, or even a bone biopsy might be needed.

Positron emission tomography (PET) scan

For a PET scan, a radioactive substance (usually a type of sugar related to glucose, known as FDG) is injected into the blood. The amount of radioactivity used is very low. Because cancer cells in the body are growing quickly, they absorb large amounts of the radioactive sugar. A special camera can then create a picture of areas of radioactivity in the body. The picture is not finely detailed like a CT or MRI scan, but it provides helpful information about the whole body.

PET scans can be helpful in showing the spread of osteosarcomas to the lungs, other bones, or other parts of the body, and also in following the response to treatment.

Some newer machines can do a PET and CT scan at the same time (PET/CT scan). This lets the doctor compare areas of higher radioactivity on the PET with the more detailed appearance of that area on the CT.

Biopsy

Although the results of imaging tests may strongly suggest that cancer is present, a biopsy (removing some of the tumor to be looked at under a microscope and other lab testing) is the only way to be certain. A biopsy is also the best way to tell osteosarcoma from other types of cancer.

If the tumor is in a bone, it is very important that a surgeon experienced in treating bone tumors does the biopsy.

Whenever possible, the biopsy and surgical treatment should be planned together, and the same orthopedic surgeon should do both the biopsy and the surgery. Proper planning of the biopsy location and technique can prevent later complications and reduce the amount of surgery needed later on.

There are 2 main types of biopsies.

Needle biopsy

These biopsies use a hollow needle to remove a small sample of the tumor. They are usually done with local anesthesia, where numbing medicine is injected into the tissue over the biopsy site. In some cases, sedation or general anesthesia (where the patient is asleep) may be needed.

Often, the doctor can aim the needle by feeling the suspicious area if it is near the surface of the body. If the tumor cannot be felt because it is too deep, the doctor can guide the needle while viewing a CT scan. This is called a *CT guided needle biopsy*.

Core needle biopsy: In a core needle biopsy, the doctor uses a large, hollow needle to remove a small cylinder of tissue from the tumor.

Fine needle aspiration (FNA) biopsy: For an FNA biopsy, the doctor uses a very thin needle attached to a syringe to withdraw (aspirate) a small amount of fluid and some cells from the tumor mass. This type of biopsy is rarely used for bone tumors.

Surgical (open) biopsy

In an open biopsy, the surgeon cuts through the skin, exposes the tumor, and then cuts out a piece of it. These biopsies are usually done under general anesthesia (with the patient asleep). They can also be done using a nerve block, which makes a large area numb.

This type of biopsy must be done by an expert in bone tumors, or it's possible the chance for saving the limb may be lost. If possible, the opening through the skin used in the biopsy should be lengthwise along the arm or leg because this is the way the incision will be made for the operation to remove the cancer. The entire scar of the original biopsy will also have to be removed, so planning the biopsy incisions in this way lessens the amount of tissue that needs to be removed later on.

Lab tests

Testing the biopsy samples

All samples removed by biopsy are sent to a pathologist (doctor specializing in lab tests) to be looked at under a microscope. Tests looking for chromosome or gene changes in the tumor cells may also be done. These tests may help distinguish osteosarcoma from other cancers that look like it under the microscope and can sometimes help predict whether the osteosarcoma is likely to respond to therapy.

If an osteosarcoma is diagnosed, the pathologist will assign it a grade, which is a measure of how quickly the cancer is likely to grow and spread, based on how it looks under a microscope. Cancers that look somewhat like normal bone tissue are described as low grade, while those that look very abnormal are called high grade. For more on grading, see the section, "How is osteosarcoma staged?"

Blood tests

Blood tests are not needed to diagnose osteosarcoma, but they may be helpful once a diagnosis is made. For example, high levels of certain chemicals in the blood such as alkaline phosphatase and lactate dehydrogenase (LDH) can suggest that the osteosarcoma may be more advanced than it appears.

Other tests, such as blood cell counts and standard blood chemistry tests, are done before surgery and other treatments to get a sense of a person's overall health. These tests are also important to monitor a person's health while getting chemotherapy.

How is osteosarcoma staged?

Staging is a process the doctor uses to determine how far the cancer might have spread. The treatment and prognosis (outlook) for osteosarcoma depend, to a large extent, on the stage of the cancer when it is first diagnosed.

The stage of an osteosarcoma is based on the results of physical exams, imaging tests, and any biopsies that have been done, which were described in the section "How is osteosarcoma diagnosed?"

A staging system is a standardized way in which the cancer care team describes the extent of the cancer. There are 2 formal staging systems sometimes used to describe the extent of an osteosarcoma, which are described below. But in practice, doctors often use a simpler system that divides osteosarcomas into 2 groups – localized and metastatic – when deciding on the best course of treatment.

Localized versus metastatic osteosarcoma

Localized osteosarcoma

A localized osteosarcoma is seen only in the bone it starts in and possibly the tissues next to the bone, such as muscle, tendon, or fat. About 4 out of 5 osteosarcomas are thought to be localized when they are first found. But even when imaging tests do not show that the cancer has spread to distant areas, most patients are likely to have micrometastases (very small areas of cancer spread that can't be detected with tests), which is why chemotherapy is an important part of treatment for most osteosarcomas. If it isn't given, the cancer might be more likely to come back after surgery.

Doctors further divide localized osteosarcomas into 2 groups. Resectable cancers are those in which all of the visible tumor can be removed by surgery. Non-resectable (or unresectable) osteosarcomas cannot be completely removed by surgery.

Metastatic osteosarcoma

A metastatic osteosarcoma has clearly spread to other parts of the body such as the lungs or to other bones not directly connected to the bone the tumor started in. Most often it spreads to the lungs, but it can also spread to other bones, the brain, or other internal organs. About 1 out of 5 osteosarcoma patients has metastases at the time of diagnosis.

Patients who already have visible metastases when they are first diagnosed are harder to treat, although some can be cured if the metastases can be removed by surgery. The cure rate for these patients improves markedly if chemotherapy is also given.

Musculoskeletal Tumor Society (MSTS) Staging System

One system commonly used to stage osteosarcoma is the MSTS system, also known as the Enneking system. It is based on 3 key pieces of information:

- The grade (G) of the tumor
- The extent of the original (primary) tumor (T)
- If the tumor has metastasized (spread) (M) to nearby lymph nodes (bean-sized collections of immune system cells) or other organs

The grade (how likely the tumor is to grow and spread, based on how it looks under the microscope) is divided into low grade (G1) and high grade (G2).

The extent of the primary tumor is classified as either intracompartmental (T1), meaning it has basically remained within the bone, or extracompartmental (T2), meaning it has extended beyond the bone into other nearby structures.

Tumors that have not spread to the lymph nodes or other organs are considered M0, while those that have spread are M1.

These factors are combined to give an overall stage, using Roman numerals from I to III. Stages I and II are further divided into A for intracompartmental tumors or B for extracompartmental tumors.

Stage	Grade	Tumor	Metastasis
IA	G1	T1	M0
IB	G1	T2	M0
IIA	G2	T1	M0

IIB	G2	T2	M0
III	G1 or G2	T1 or T2	M1

In summary:

- Low-grade, localized tumors are stage I.
- High-grade, localized tumors are stage II.
- Metastatic tumors (regardless of grade) are stage III.

AJCC staging system

Another system sometimes used to stage bone cancers is the American Joint Commission on Cancer (AJCC) system. The AJCC uses one system to describe all bone cancers, including osteosarcomas. The AJCC staging system for bone cancers is based on 4 key pieces of information:

- **T** describes the size of the main (primary) tumor and whether it appears in different areas of the bone.
- **N** describes the extent of spread to nearby (regional) lymph nodes (small bean-shaped collections of immune system cells). Bone tumors rarely spread to the lymph nodes.
- **M** indicates whether the cancer has metastasized (spread) to other organs of the body. (The most common sites of spread are to the lungs or other bones.)
- **G** stands for the grade of the tumor, which is a description of how the cells look under a microscope. Low-grade tumor cells look more like normal cells, and are less likely to grow and spread quickly, while high-grade tumor cells look more abnormal.

Numbers after T, N, M, and G provide more details about each of these factors.

T categories of bone cancer

T0: There is no evidence of a main (primary) tumor.

T1: The tumor is 8 cm (around 3 inches) across or less.

T2: The tumor is larger than 8 cm across.

T3: The tumor has "skipped" to another site or sites within the same bone.

N categories of bone cancer

N0: The cancer has not spread to regional (nearby) lymph nodes.

N1: The cancer has spread to nearby lymph nodes.

M categories of bone cancer

M0: There is no distant metastasis.

M1: Distant metastasis (spread of the cancer to tissues or organs far away from the original bone tumor).

M1a: The cancer has spread only to the lung.

M1b: The cancer has spread to other distant sites in the body.

Grades of bone cancer

Note: The grades used for the AJCC system are different from those in the MSTS system. There are other differences between the systems as well. To avoid confusion, it may help to ask your (child's) doctor which staging system he or she uses.

G1, G2: Low grade

G3, G4: High grade

Stage grouping

Once the T, N, and M categories and the grade of the bone cancer have been determined, the information is combined into an overall stage. The process of assigning a stage number is called *stage grouping*. The stages are described in Roman numerals from I to IV (1 to 4), and are sometimes divided further.

Stage IA

T1, N0, M0, G1-G2: The tumor is 8 cm across or less and is low grade. It has not spread to nearby lymph nodes or to distant parts of the body.

Stage IB

T2-T3, N0, M0, G1-G2: The tumor is larger than 8 cm across or has "skipped" to other sites in the same bone. It is low grade. It has not spread to nearby lymph nodes or to distant parts of the body.

Stage IIA

T1, N0, M0, G3-G4: The tumor is 8 cm across or less and is high grade. It has not spread to nearby lymph nodes or to distant parts of the body.

Stage IIB

T2, N0, M0, G3-G4: The tumor is larger than 8 cm across and is high grade. It has not spread to nearby lymph nodes or to distant parts of the body.

Stage III

T3, N0, M0, G3-G4: The tumor has "skipped" to other sites in the same bone. It is high grade. It has not spread to nearby lymph nodes or to distant parts of the body.

Stage IVA

Any T, N0, M1a, any G: The tumor has spread only to the lungs. It has not spread to the lymph nodes or to other distant sites. (It can be any size or grade.)

Stage IVB (if either of these applies)

Any T, N1, any M, any G: The tumor has spread to lymph nodes. It can be any size or grade, and may or may not have spread to other distant sites.

Any T, any N, M1b, any G: The tumor has spread to distant sites other than the lung. It can be any size or grade.

What are the survival rates for osteosarcoma?

Survival rates are often used by doctors as a standard way of discussing the prognosis (outlook) of a person with a certain type and stage of cancer. Some patients or parents of children with cancer may want to know the survival statistics for people in similar situations, while others may not find the numbers helpful, or may even not want to know them. Whether or not you want to read about the survival statistics below for osteosarcoma is up to you.

The 5-year survival rate refers to the percentage of patients who live *at least 5 years* after their cancer is diagnosed. Of course, many people live much longer than 5 years (and many are cured).

In order to get 5-year survival rates, doctors have to look at people who were treated at least 5 years ago. Advances in treatment since then may mean a more favorable outlook for people now being diagnosed with osteosarcoma.

Survival rates are often based on previous outcomes of large numbers of people who had the disease, but they cannot predict what will happen in any particular person's case. Many other factors can affect a person's outlook, such as the subtype and location of the osteosarcoma and how well the cancer responds to treatment. Your (child's) doctor can tell you if the numbers below may apply, as he or she is familiar with the aspects of your (child's) particular situation.

Localized tumors

With modern treatment, the 5-year survival rate for patients with a localized osteosarcoma is in the range of 60% to 80%.

Metastatic tumors

When metastases are present at diagnosis, the 5-year survival rate is about 15% to 30%. The survival rate is closer to 40% if the cancer has spread only to the lungs (as opposed to having reached other organs), or if all of the tumors (including metastases) can be removed with surgery.

Other factors that may affect prognosis

As noted above, factors other than the stage of the cancer can also affect survival rates. For example, factors that have been linked with a better prognosis include:

- Younger age (child or young adult, as opposed to older adult)
- Female gender
- Tumor is located on an arm or leg (as opposed to the hip bones)
- Tumor(s) can be completely resected
- Normal blood alkaline phosphatase and LDH levels
- Good tumor response to chemotherapy

How is osteosarcoma treated?

This information represents the views of the doctors and nurses serving on the American Cancer Society's Cancer Information Database Editorial Board. These views are based on their interpretation of studies published in medical journals, as well as their own professional experience.

The treatment information in this document is not official policy of the Society and is not intended as medical advice to replace the expertise and judgment of your cancer care team. It is intended to help you and your family make informed decisions, together with your doctor.

Your doctor may have reasons for suggesting a treatment plan different from these general treatment options. Don't hesitate to ask him or her questions about your treatment options.

General treatment information

Great advances have been made in the treatment of osteosarcoma during the past several decades. In the 1960s the only treatment available was amputation, and only a small number of patients survived 2 years or more after diagnosis.

Since that time, doctors have found that chemotherapy given before and after surgery will cure many people with osteosarcoma. It may also allow some people who previously would have needed to have the affected limb amputated to have limb-sparing surgery instead.

Making treatment decisions for osteosarcoma

After an osteosarcoma is found and staged, the cancer care team will talk with you about your treatment options. It is important to take time and think about your options. Because osteosarcoma is rare, only doctors in major cancer centers have a lot of experience in treating these cancers.

For children, a team approach is recommended that includes the child's pediatrician as well as specialists (such as pediatric oncologists and orthopedic surgeons). Treatment is best done at a children's cancer center.

For adults with osteosarcoma, the treatment team typically includes the patient's primary care doctor, as well as specialists at a major cancer center:

- An orthopedic surgeon (a surgeon who specializes in muscles and bones) experienced in treating bone tumors
- A medical oncologist (a doctor trained to treat cancer with chemotherapy and other drugs)
- A radiation oncologist (a doctor trained to treat cancer with radiation therapy)
- A pathologist (a doctor specializing in lab tests to diagnose and classify diseases)

In both cases, the team would also include other doctors, nurses, rehabilitation therapists, and technologists who have essential roles in diagnosing and treating the disease and assisting in recovery after surgery.

The types of treatment used for osteosarcomas include:

- Surgery
- Chemotherapy
- Radiation therapy (in certain cases)

In most cases, both chemotherapy and surgery are needed.

All of these treatments may have side effects, but many of them can be made less troublesome. Your medical team will help you take care of the side effects and will work closely with nutritionists, psychologists, and social workers to help you understand and deal with the medical problems, stress, and scheduling issues related to the treatment.

Because many of these things can be more complicated for cancer in children, many people will be involved in your child's overall care. As a parent, taking care of a child with cancer can be a very big job. It is important to remember that you will have a lot of help. It is also important for you to know that the health care professionals who treat children with osteosarcoma are using the experience and knowledge gained from many decades of detailed scientific study of treating this disease.

The following sections describe the types of treatment used for osteosarcomas and when these treatments are used in different situations.

Surgery for osteosarcoma

Surgery for osteosarcoma includes both the biopsy to diagnose the cancer and the surgical treatment. Surgery is an important part of treatment for virtually all osteosarcomas.

Whenever possible, it is very important that the biopsy and surgical treatment be planned together, and that the same orthopedic surgeon at a cancer center does both the biopsy and the surgical treatment.

The main goal of surgery is to remove all of the cancer. If even a few cancer cells are left behind, they can grow and multiply to make a new tumor. To try to be sure that this doesn't happen, surgeons remove the tumor plus some of the normal tissue that surrounds it. This is known as *wide excision*. Removing some normal-looking tissue around the tumor raises the chance that all of the cancer is removed.

A pathologist will look at the tissue under a microscope to see if the margins (outer edges) contain cancer cells. If cancer cells were seen at the edges of the tissue, the margins are called *positive*. Positive margins can mean that some cancer was left behind. When no cancer cells are seen at the edges of the tissue, the margins are said to be *negative, clean, or clear*. A wide excision with clean margins minimizes the risk that the cancer will grow back where it started.

The type of surgery done depends on the location of the tumor. Although all of these operations are complex, tumors in the limbs (arms or legs) are generally not as hard to remove as those at the base of the skull, in the spine, or in the pelvis.

Tumors in the arms or legs

Tumors in the arms or legs may be treated with either limb-salvage (limb-sparing) surgery (removing the cancer without amputation) or amputation (removing the cancer and all or part of an arm or leg).

Limb-salvage surgery: Most patients with tumors in the arms or legs can have limb-sparing surgery, but this depends on the location and extent of the tumor.

Limb-salvage surgery is a very complex operation. The surgeons who do this type of operation must have special skills and experience. The challenge for the surgeon is to remove the entire tumor while still saving the nearby tendons, nerves, and blood vessels to keep as much of the limb's function and appearance as possible. But if a cancer has grown into these structures, they will need to be removed along with the tumor. In such cases, amputation may sometimes be the best option.

The section of bone that is removed is replaced with a bone graft (piece of bone from another part of the body or from another person) or with an internal prosthesis (a man-made device used to replace part or all of a bone) made of metal and other materials.

Complications of limb-salvage surgery can include infections and grafts or rods that become loose or broken. Limb-salvage surgery patients may need more surgery during the following years, and some may eventually need an amputation.

Using an internal prosthesis in growing children is especially challenging. Traditionally, it has required occasional operations to replace the prosthesis with a longer one as the child grows. Newer prostheses have become very sophisticated. Some can be made longer without any extra surgery. They have tiny devices in them that can lengthen the prosthesis when needed to make room for a child's growth. But even these prostheses may need to be replaced with a stronger adult prosthesis once the child's body stops growing.

It takes about a year, on average, for patients to learn to walk after limb-salvage surgery on a leg. This physical rehabilitation is more intense than after amputation. If the patient does not take part in the rehabilitation program, the salvaged arm or leg may become useless.

Amputation: For some patients, amputation may be the best option. For example, if the patient has a large tumor that extends into the nerves and/or the blood vessels, it may not be possible to save the limb.

Results of MRI scans and examination of the tissue by the pathologist during surgery can help the surgeon decide how much of the arm or leg needs to be amputated. Surgery is planned so that muscles and the skin will form a cuff around the remaining bone. This cuff will fit into the end of a prosthetic (artificial) limb.

Reconstruction techniques have been developed to help patients with limb loss function as well as possible. Sometimes, if the leg must be amputated mid-thigh, the lower leg and foot is rotated and attached to the thigh bone, so that the ankle functions as a new knee joint. This surgery is called *rotationplasty*. Of course, the patient would still need a prosthetic limb to extend the leg.

With proper physical therapy, the patient is often able to walk on his/her own 3 to 6 months after leg amputation.

If the osteosarcoma is located in the upper arm, in some cases the tumor may be removed and the lower arm reattached so that the patient has a functional, but much shorter, arm.

Rehabilitation after surgery: This may be the hardest part of all the treatments, and this discussion cannot describe it completely. Patients and parents should meet with a rehabilitation specialist before surgery to learn about their options and what may be required after surgery.

If a limb is amputated, the patient must learn to live with and use a prosthetic limb. This can be particularly hard for growing children if the prosthetic limb needs to be changed to keep up with their growth.

When only the tumor and part of the bone is removed in a limb-sparing operation, the situation can be even more complicated, especially in growing children. Further

operations might be needed to replace the internal prosthesis with one more suited to their growing body size.

Both types of surgery have problems associated with them as well as possible benefits. For example, limb-sparing surgery, although more acceptable to most patients than amputation, tends to lead to more complications because of its complexity. Growing children who have limb-sparing surgery are also more likely to need further surgery down the road. Perhaps surprisingly, people with amputations can often be more physically active, as the affected limb can tolerate more physical stress than one with an internal prosthesis.

When researchers have looked at the final results of the different surgeries in terms of quality of life, there has been little difference between them. Perhaps the biggest problem has been for teens who fear the social effects of their operation. Emotional issues can be very important, and support and encouragement are needed for all patients (see "What happens after treatment for osteosarcoma?").

Tumors that start in other areas

Pelvic tumors can often be hard to remove completely with surgery. But if the tumor responds well to chemotherapy first, surgery (sometimes followed by radiation therapy) may get rid of all of the cancer. Pelvic bones can often be reconstructed after surgery.

For a tumor in the lower jaw bone, the entire lower half of the jaw may be removed and later replaced with bones from other parts of the body. If the surgeon can't remove all of the tumor, radiation therapy may be used as well.

For tumors in areas like the spine or the skull, it may not be possible to remove all of the tumor safely. Cancers in these bones may require a combination of treatments such as chemotherapy, surgery, and radiation.

Surgical treatment of metastases

If the osteosarcoma has spread to other parts of the body, these tumors need to be removed to have a chance at curing the cancer.

When osteosarcoma spreads, most often it is to the lungs. Surgery to remove these metastases must be planned very carefully. Before the operation, the surgeon considers the number of tumors, their location (one lung or both lungs), their size and response to chemotherapy, and the general health of the patient. Since the chest CT scan may not show all the tumors that truly exist, the surgeon will have a treatment plan in case more tumors are found during the operation.

Patients who have tumors in both lungs and respond well to chemotherapy can have surgery on one side of the chest at a time. Removing tumors from both lungs at the same time may be another option.

Some lung metastases may not be able to be removed because they are too big or are too close to important structures in the chest (such as large blood vessels). Patients whose

general health is not good (because of poor nutritional status or problems with the heart, liver, or kidneys) may not be able to withstand the stress of anesthesia and surgery to remove metastases.

A small number of osteosarcomas spread to other bones or to the kidneys, liver, or brain. Whether or not these tumors can be removed with surgery depends on their size, location, and other factors.

For more information on surgery as a treatment for cancer, see our document, *Surgery*.

Chemotherapy for osteosarcoma

Chemotherapy is the use of drugs for treating cancer, which are usually given into a vein or artery. The drugs enter the bloodstream and reach and destroy cancer cells throughout the body.

In many cases, osteosarcoma has spread to the lungs and/or other organs or has a high risk of doing so, even if tumors can't be seen on imaging tests. Because of this, chemotherapy is an important part of the treatment for most osteosarcomas, although some patients with low-grade osteosarcoma may not need it.

Doctors give chemotherapy in cycles, with each period of treatment followed by a rest period to allow the body time to recover. Each chemotherapy cycle typically lasts for a few weeks.

Most cases of osteosarcoma are treated with chemotherapy given before surgery (neoadjuvant chemotherapy) for about 10 weeks and again after surgery (adjuvant chemotherapy) for up to a year. People with high-grade osteosarcoma whose tumors responded well to chemotherapy before surgery usually get the same chemotherapy after surgery. People whose tumors responded poorly usually will get different chemotherapy after surgery.

The drugs used most often to treat osteosarcoma include:

- Methotrexate (given in high doses along with leucovorin to help prevent side effects)
- Doxorubicin (Adriamycin)
- Cisplatin or carboplatin
- Etoposide
- Ifosfamide
- Cyclophosphamide
- Epirubicin
- Gemcitabine
- Topotecan

Usually, several drugs are given together. Some common combinations of drugs include:

- High-dose methotrexate, doxorubicin, and cisplatin (sometimes with ifosfamide)
- Doxorubicin and cisplatin
- Ifosfamide and etoposide
- Ifosfamide, cisplatin, and epirubicin

Many experts recommend that the drugs be given in very high doses, which can affect the bone marrow, where new blood cells are made. In these cases, other drugs called growth factors (such as filgrastim, also known as Neupogen) may be given to help the body make new blood cells as quickly as possible.

Side effects of chemotherapy

Chemotherapy drugs work by attacking cells that are dividing quickly, which is why they work against cancer cells. But other cells in the body, such as those in the bone marrow, the lining of the mouth and intestines, and the hair follicles, also divide quickly. These cells are also likely to be affected by chemotherapy, which can lead to side effects.

Children seem to have an advantage over adults when it comes to chemotherapy. They tend to have less severe side effects and recover from side effects more quickly. Because of this, doctors can give them higher doses of chemotherapy to try to kill the tumor.

The side effects of chemotherapy depend on the type and dose of drugs given and the length of time they are taken.

General side effects: Many chemotherapy drugs can cause side effects such as nausea and vomiting, loss of appetite, diarrhea, hair loss, and mouth sores.

Because chemotherapy can damage the blood-producing cells of the bone marrow, patients may have low blood cell counts. Low blood cell counts can result in:

- Increased chance of infection (from a shortage of white blood cells)
- Bleeding or bruising after minor cuts or injuries (from a shortage of platelets)
- Fatigue or shortness of breath (from low red blood cell counts)

Most of these side effects are short-term and tend to go away after treatment is finished. Often there are ways to lessen these side effects. For example, drugs can be given to help prevent or reduce nausea and vomiting. Be sure to discuss any questions you have about side effects with the cancer care team, and tell them about any side effects you have so that they can be prevented or controlled.

Side effects of certain drugs: Some side effects are specific to particular drugs. Many of these side effects are rare, but they are possible. Before treatment, ask your cancer care team about the possible side effects of the drugs you or your child will be getting.

Ifosfamide and cyclophosphamide can damage the lining of the bladder, which can cause blood in the urine. This is called *hemorrhagic cystitis*. The chance of this happening can be lowered by giving a drug called mesna during chemotherapy, along with plenty of fluids.

Cisplatin and carboplatin may cause nerve damage (called *neuropathy*) leading to problems with numbness, tingling, or pain in the hands and feet. Kidney damage (called *nephropathy*) can also occur after treatment. Giving lots of fluid before and after the drug is infused can help prevent this side effect. These drugs can sometimes cause problems with hearing (known as *ototoxicity*). Most often patients with this problem notice problems hearing high-pitched sounds.

Etoposide can also cause nerve damage. It can also increase the risk of later developing a cancer of white blood cells, known as acute myeloid leukemia. Fortunately, this is not common.

High-dose methotrexate may cause damage to the white matter of the brain (called *leukoencephalopathy*) and liver or kidney damage. Before starting high-dose methotrexate, medicines are given to help protect the kidneys. Methotrexate blood levels may be checked to see how much leucovorin (also called folinic acid) should be given to help stop any damage to normal tissues.

Doxorubicin (Adriamycin) and epirubicin can cause heart damage over time. The risk of this happening goes up as the total amount of the drug that is given goes up. Your (child's) doctor may order a test of heart function before and during treatment to see if this drug is affecting the heart. Another drug called dexrazoxane may be given along with the chemotherapy to help lessen the possible damage.

The doctors and nurses will watch closely for side effects. Do not hesitate to ask your cancer care team any questions about side effects.

Long-term side effects: Some side effects may not go away or may not happen until years after treatment is finished. Examples include:

- Infertility (being unable to have children)
- Heart damage
- Developing a second cancer

Some of these long-term effects are described in the section, "What happens after treatment for osteosarcoma?"

Tests to check for side effects of chemotherapy: Before giving these drugs, your (child's) doctor will check lab test results to be sure the liver, kidney, and bone marrow are functioning well.

The complete blood count (CBC) includes counts of white blood cells, red blood cells, and blood platelets. Chemotherapy can lower the numbers of these blood cells, so blood counts will be watched closely during and after chemotherapy. The cells usually reach

their lowest point about 2 weeks after chemotherapy is given, though this can occur earlier with high-dose regimens.

Routine blood chemistry panels measure certain blood chemicals that tell doctors how well the liver and the kidneys are working. Some drugs used in chemotherapy can damage the kidneys and liver.

An audiogram may be done to check the patient's hearing, which may be affected by certain chemotherapy drugs.

If doxorubicin or epirubicin is to be given, tests such as an echocardiogram (an ultrasound of the heart) may be done to check heart function.

For more information on chemotherapy, see the document, *Understanding Chemotherapy: A Guide for Patients and Families*.

Radiation therapy for osteosarcoma

Radiation therapy uses high-energy rays or particles to kill cancer cells. Osteosarcoma cells are not easily killed by radiation, so radiation therapy does not play a major role in treating this disease.

External beam radiation therapy

This is the type of radiation therapy most often used as a treatment for osteosarcoma.

Before treatments start, the radiation team takes careful measurements with imaging tests such as MRI scans to determine the correct angles for aiming the radiation beams and the proper dose of radiation.

External radiation therapy is much like getting an x-ray, although the dose of radiation is much higher. For each session, you (or your child) will lie on a special table while a machine delivers the radiation from a precise angle. The treatment is not painful.

Each actual treatment lasts only a few minutes, although the setup time – getting you (or your child) into place for treatment – usually takes longer. Young children may be given medicine to make them fall asleep so they will not move during the treatment. Most often, radiation treatments are given 5 days a week for several weeks.

Several newer techniques, such as intensity modulated radiation therapy (IMRT) and conformal proton beam therapy, may allow doctors to more accurately aim treatment at the tumor while reducing the radiation exposure to nearby healthy tissues. These techniques may offer better chances of increasing the success rate and reducing side effects. Many doctors now recommend using these approaches when they are available.

Radiation therapy may be useful in some cases where the tumor cannot be completely removed by surgery. For example, osteosarcoma can start in pelvic bones or in the bones of the face, particularly the jaw. In these situations, it is often not possible to completely

remove the cancer. As much as possible is removed, and then radiation is given to try to kill the remaining cancer. Chemotherapy may be used after radiation.

Radiation can also be helpful in controlling symptoms like pain and swelling if the cancer has come back or surgery is not possible.

The possible side effects of external radiation therapy depend on the dose of radiation and where it is aimed. Short-term side effects may include skin reactions (often like a sunburn) and fatigue. Often these go away after a short while. Talk with your child's doctor about the possible side effects because there may be ways to relieve some of them.

In children, radiation therapy can interfere with the growth of normal body tissues, including the bones, and may increase the risk of their developing other cancers later on. To lower the risk of serious long-term effects from radiation, doctors try to use the lowest dose of radiation therapy that is still effective.

Radioactive drugs (radiopharmaceuticals)

Bone-seeking radioactive drugs, such as samarium-153, are also sometimes used to treat symptoms such as pain in people with advanced osteosarcoma. They are injected into a vein and collect in bones. Once there, the radiation they give off kills the cancer cells and relieves some of the pain caused by bone metastases.

These drugs are especially helpful when cancer has spread to many bones, since external beam radiation would need to be aimed at each affected bone. In some cases, these drugs are used together with external beam radiation aimed at the most painful bone metastases.

The major side effect of these drugs is a lowering of blood cell counts, which could increase the risk for infections or bleeding, especially if the blood counts are already low.

For more detailed information on radiation therapy, see *Understanding Radiation Therapy: A Guide for Patients and Families*.

Clinical trials for osteosarcoma

You may have had to make a lot of decisions since you've been told you (or your child) has cancer. One of the most important decisions you will make is deciding which treatment is best. You might have heard about clinical trials being done for this type of cancer. Or maybe someone on your health care team has mentioned a clinical trial to you.

Clinical trials are carefully controlled research studies that are done with patients who volunteer for them. These studies are done to get a closer look at promising new treatments or procedures.

If you would like to find out more about clinical trials you (or your child) may be eligible for, you should start by asking your doctor if your clinic or hospital conducts clinical trials. You can also call our clinical trials matching service for a list of clinical trials that meet your medical needs. You can reach this service at 1-800-303-5691 or on our Web site at www.cancer.org/clinicaltrials. You can also get a list of current clinical trials by

calling the National Cancer Institute Cancer Information Service toll free at 1-800-4-CANCER (1-800-422-6237) or by visiting the NCI clinical trials Web site at www.cancer.gov/clinicaltrials.

People have to meet certain requirements to take part in any clinical trial. If you (or your child) qualify for a clinical trial, you will have to decide whether or not to enter (enroll) into it. Older children, who can understand more, usually must also agree to take part in the clinical trial before the parents' consent is accepted.

Clinical trials are one way to get state-of-the-art cancer care. They are the only way for doctors to learn better methods to treat cancer. Still, they are not right for everyone.

You can get a lot more information on clinical trials in our document called *Clinical Trials: What You Need to Know*. You can read it on our Web site or call our toll-free number (1-800-227-2345) and have it sent to you.

Complementary and alternative therapies for osteosarcoma

You might hear about ways to treat cancer or relieve symptoms that are different from mainstream (standard) medical treatment. Everyone from friends and family to Internet groups and Web sites may offer ideas for what might help you or your child. These methods can include vitamins, herbs, and special diets, or other methods such as acupuncture or massage, to name a few.

What exactly are complementary and alternative therapies?

Not everyone uses these terms the same way, and they are used to refer to many different methods, so it can be confusing. We use *complementary* to refer to treatments that are used *along with* your regular medical care. *Alternative* treatments are used *instead of* a doctor's medical treatment.

Complementary methods: Most complementary treatment methods are not offered as cures for cancer. Mainly, they are used to help the person with cancer feel better. Some methods that are used along with regular treatment are: art therapy or play therapy to reduce stress; acupuncture to help relieve pain; or peppermint tea to relieve nausea. Some complementary methods are known to help, while others have not been tested. Some have been proven not to be helpful, and a few have even been found harmful.

Alternative treatments: Alternative treatments may be offered as cancer cures. These treatments have not been proven safe and effective in clinical trials. Some of these methods may pose danger, or have life-threatening side effects. But the biggest danger in most cases is that you (or your child) may lose the chance to be helped by standard medical treatment. Delays or interruptions in medical treatments may give the cancer more time to grow and make it less likely that treatment will help.

Finding out more

It is easy to see why people with cancer (or with children who have cancer) think about alternative methods. You want to do all you can to help fight the cancer, and the idea of a treatment with few or no side effects sounds great. Sometimes medical treatments like chemotherapy can be hard to take, or they may no longer be working. But the truth is that most of these alternative methods have not been tested and proven to work in treating cancer.

As you consider your options, here are 3 important steps you can take:

- Look for "red flags" that suggest fraud. Does the method promise to cure all or most cancers? Are you told not to use regular medical treatments? Is the treatment a "secret" that can only be given by certain providers or in another country?
- Talk to your (child's) doctor or nurse about any method you are thinking about.
- Contact us at 1-800-227-2345 to learn more about complementary and alternative methods in general and to find out about the specific methods you are looking at.

The choice is yours

You always have a say in your (or your child's) treatment. If you want to use a non-standard treatment, learn all you can about the method and talk to your doctor about it. With good information and the support of the health care team, you may be able to safely use the methods that can help while avoiding those that could be harmful.

Treatment based on the extent of the osteosarcoma

Treatment for osteosarcoma depends on several factors, including the extent, location, and grade of the cancer, and on a person's overall health.

Localized, resectable osteosarcoma

These cancers have not spread to other parts of the body, and all of the visible tumor can be completely removed (resected) by surgery.

High-grade: Most osteosarcomas are high grade, meaning they may grow and spread quickly if not treated. The usual sequence of treatment for these cancers is as follows:

- Biopsy to establish the diagnosis
- Chemotherapy (usually for about 10 weeks)
- Surgery
- More chemotherapy (for up to a year)

Chemotherapy is an important part of treatment for these cancers. Even when imaging tests do not show that the cancer has spread to distant areas, some patients are likely to

have micrometastases (very small areas of cancer spread that can't be detected with tests). If chemotherapy isn't given, the cancer is more likely to come back after surgery.

Low-grade: A small number of osteosarcomas are low grade, meaning they are likely to grow slowly. Patients with low-grade, resectable osteosarcomas can often be cured with surgery alone (without chemotherapy). Studies have shown that these patients do just as well having surgery without chemotherapy.

However, if after surgery the tumor is found to be high grade when viewed by the pathologist, chemotherapy will be recommended.

Localized, non-resectable osteosarcoma

These cancers have not spread to other parts of the body, but they can't be completely removed by surgery. For example, they may be too large or too close to vital structures in the body to be resected completely. As with other osteosarcomas, a biopsy is needed first to establish the diagnosis.

Chemotherapy is usually the first treatment for these cancers. If the tumor shrinks enough to become resectable, it is then treated with surgery to remove the visible tumor. This is followed by more chemotherapy for up to a year.

If the tumor is still unresectable after chemotherapy, radiation therapy can often be used to try to keep the tumor in check and to help relieve symptoms. This may be followed by more chemotherapy.

Metastatic osteosarcoma

These cancers have already spread to distant parts of the body when they are diagnosed. Most often they have spread to the lungs. As with other osteosarcomas, a biopsy is needed first to establish the diagnosis.

Chemotherapy is usually the first treatment for these cancers. If all of the tumors are thought to be resectable after chemotherapy, they are removed with surgery, which may require more than one operation. This is followed by more chemotherapy for up to a year.

If some of the tumors remain unresectable after chemotherapy, radiation therapy can often be used to try to keep them in check and to help relieve symptoms. This may be followed by more chemotherapy. Because these tumors can be hard to treat, clinical trials of newer treatments may be a good option in many cases.

Recurrent osteosarcoma

Recurrent cancer means that the cancer comes back after treatment. It may come back locally (near where the first tumor was) or in distant organs. Most of the time, osteosarcoma recurs in the lungs.

If it is possible, surgery to remove the tumor(s) is the preferred treatment as it offers the best chance for long-term survival. If the cancer recurs at the original site on an arm or leg after limb-sparing surgery, amputation of the limb may be recommended.

Chemotherapy may be used for recurrent cancers as well, although its role in these cases is not clearly defined. If the cancer is not resectable, radiation therapy may also be used to help keep its growth in check and help relieve symptoms. Because these tumors can be hard to treat, clinical trials of newer treatments may be a good option.

More treatment information for osteosarcoma

For more details on treatment options – including some that may not be addressed in this document – other good sources of information include the National Comprehensive Cancer Network (NCCN), the National Cancer Institute (NCI), and CureSearch.

The NCCN, made up of experts from the nation's leading cancer centers, develops cancer treatment information for doctors to use when treating patients. These are available on the NCCN Web site (www.nccn.org).

The NCI provides treatment information via its telephone information center (1-800-4-CANCER) and its Web site (www.cancer.gov). Detailed information intended for use by cancer care professionals is also available on www.cancer.gov.

CureSearch is a combined effort of the National Childhood Cancer Foundation and the Children's Oncology Group (COG). CureSearch can be contacted via telephone at 1-800-458-6223 or on the Web at www.curesearch.org.

What should you ask the doctor about osteosarcoma?

It is important to have frank, open discussions with your cancer care team. They want to answer all of your questions no matter how minor they might seem. For instance, consider these questions:

- What kind of osteosarcoma do I (does my child) have? Will this affect treatment?
- Has the cancer spread beyond the bone it started in?
- What is the stage of the cancer and what does that mean?
- Are there other tests that need to be done before we can decide on treatment?
- How much experience do you have treating this disease?
- What other doctors will I (we) need to see?
- What are our treatment options?
- What do you recommend and why?

- How long will treatment last? What will it involve? Where will it be done?
- How will treatment affect our daily lives?
- What should I (we) do to be ready for treatment?
- What are the possible short and long-term side effects of the suggested treatments?
- Are there fertility issues we need to consider?
- What are the chances of recurrence with these treatment plans? What would we do if this happens?
- What type of follow up and rehabilitation will be needed after treatment?

Along with these sample questions, be sure to write down some of your own. For instance, you might want more information about recovery times so you can plan a work or school schedule. You may also want to ask about second opinions or about available clinical trials.

What happens after treatment for osteosarcoma?

Following treatment for osteosarcoma, the main concerns for most people are the immediate and long-term effects of the tumor and its treatment, and concerns about possible recurrence of the tumor.

Follow-up care

After treatment is over, it is very important to go to all follow-up appointments. During these visits, doctors will ask about symptoms, do physical exams, and may order blood tests or imaging tests such as CT scans or x-rays. Follow-up is needed to check for cancer recurrence or spread, as well as possible side effects of certain treatments. This is the time for you to ask the health care team any questions you need answered and to discuss any concerns you might have.

You or your child will probably see the oncologist and the orthopedic surgeon every few months during the first year after treatment, and less often thereafter. Physical exams, x-rays or CT scans of the chest, and x-rays of the affected bone are typically recommended about every 3 to 4 months for 3 years, every 6 months in years 4 and 5, and once a year after that.

Some chemotherapy drugs can cause problems with hearing or heart damage. People who get these drugs may also have audiograms to check hearing or tests to check heart function.

Almost any cancer treatment can have side effects. Some may last for a few weeks to several months, but others can be permanent. Tell the cancer care team about any symptoms or side effects so they can help manage them.

It is certainly understandable to want to put the tumor and its treatment behind you and to get back to a life that doesn't revolve around cancer. But it's important to realize that follow-up care is a central part of this process that offers you (or your child) the best chance for recovery and long-term survival.

It is also important to keep medical insurance. Even though no one wants to think of the cancer coming back, it is always a possibility. If it happens, the last thing you want is to have to worry about paying for treatment.

Keeping good medical records

As much as you may want to put the experience behind you once treatment is completed, it is also very important to keep good records of your (child's) medical care during this time. This can be very helpful later on if you (or your child) change doctors. Be sure the doctors have the following information:

- A copy of the pathology report(s) from any biopsies or surgeries
- If there was surgery, a copy of the operative report(s)
- If there were hospitalizations, copies of the discharge summaries that doctors prepare when patients are sent home
- If there was chemotherapy treatment for the cancer, a list of the drugs, drug doses, and when they were given
- If there was radiation, a summary of the type and dose of radiation and when and where it was given

Social, emotional, and other issues in people with osteosarcoma

Most cases of osteosarcoma develop during the teenage years, a very sensitive time in a child's life. An osteosarcoma diagnosis can have a profound effect on a person's outward appearance and how they view themselves and their body. It can also affect the ability to do some everyday tasks. This can have an impact on their ability to continue certain school, work, or recreational activities. The effect will probably be greatest during the first year of treatment. The treating center should evaluate the family situation as soon as possible, so that any areas of concern can be addressed.

Some common family concerns include financial stresses, transportation to the cancer center, the possible loss of a job, and the need for home schooling. Cancer care teams usually recommend that school-age children attend school as much as possible. This helps patients maintain important social connections and gives them a chance to tell their friends what is happening to them.

Friends can be a great source of support, but you should know that some people have misunderstandings and fears about cancer. Some cancer centers have a school re-entry

program that can help in situations like this. In this program, health educators visit the school and tell students about the diagnosis, treatment, and changes the person may go through. They will also answer any questions from teachers and classmates.

Centers that treat many patients with osteosarcoma might have programs to introduce new patients to others who have already completed their therapy. Seeing another person with osteosarcoma doing well is often helpful. There are also support groups that encourage athletics and full use of the child's limbs. Many amputees or people with prostheses are able to take part in athletics and often do.

Although the psychological impact of this disease in children and teenagers is most obvious, the challenges faced by adults with this disease must not be ignored. Adult patients should also be encouraged to take advantage of the cancer centers' physical therapy, occupational therapy, and counseling services.

Long-term effects of cancer treatment for osteosarcoma

Because of significant advances in treatment, more young people treated for cancer are now living longer lives. Doctors have learned that the treatment may affect children's health later in life, so watching for health effects as they get older has become more of a concern in recent years.

Just as the treatment of cancer in young people requires a very specialized approach, so does the care and follow-up after treatment. The earlier any problems can be recognized, the more likely it is they can be treated effectively.

Young people with cancer are at risk, to some degree, for several possible late effects of their cancer treatment. This risk depends on a number of factors, such as the type of cancer, the specific cancer treatments they received, doses of cancer treatment, and age when receiving treatment.

Infertility

Infertility is not a common side effect of the treatment for osteosarcoma, but it can occur. Older girls and women may have changes in menstrual periods, but normal monthly cycles usually return after chemotherapy ends. Boys and men may lose the ability to make sperm. This usually returns, but the sperm count may remain low.

Talk to your (child's) cancer care team about the risks of infertility with treatment, and ask if there are options for preserving fertility, such as sperm banking. For more information, see our document, *Fertility and Cancer: What Are My Options?*

Development of a second cancer

Rarely, some types of chemotherapy may cause a second type of cancer (such as leukemia), years after the osteosarcoma is cured. Radiation therapy can also raise the risk of a new cancer developing at the site of the treatment. However, the importance of treating the osteosarcoma effectively generally far outweighs this risk.

Other late effects

The late effects of osteosarcoma treatment can also include heart damage or hearing problems after receiving certain chemotherapy drugs.

Long-term follow-up care for children

To help increase awareness of late effects and improve follow-up care of childhood cancer survivors throughout their lives, the Children's Oncology Group (COG) has developed long-term follow-up guidelines for survivors of childhood cancers. These guidelines, written for doctors and other health care professionals, describe in detail the suggested long-term follow-up care based on the treatments the child has received.

It is very important to discuss possible long-term complications with your child's health care team, and to make sure there is a plan in place to watch for these problems and treat them, if needed. To learn more, ask your child's doctors about the COG survivor guidelines, and see the document, *Childhood Cancer: Late Effects of Cancer Treatment*.

What's new in osteosarcoma research and treatment?

Research on osteosarcoma is now being done at many medical centers, university hospitals, and other institutions across the world.

Understanding osteosarcoma

Researchers are making progress in learning about the causes of osteosarcoma. It is hoped that more information about the DNA changes that cause this cancer will eventually result in the development of specific treatments to correct these changes. Tests of gene changes called *gene expression profiling* may help predict the behavior of each tumor, such as how they respond to certain types of chemotherapy. These are still being tested in clinical trials.

Treatment

Great advances have been made in treating osteosarcoma in the past few decades. There are many clinical trials focusing on treating osteosarcoma using a variety of strategies.

Surgery

Doctors now have a much better understanding of the typical growth and spread of osteosarcomas than they did in the past. This, along with newer imaging tests that better define the extent of tumors, lets them plan surgeries that remove the cancer while sparing as much normal tissue as possible.

Some newer types of internal prostheses (man-made devices used to replace pieces of bone) can now be expanded without the need for more surgery. This is especially important for children, who in the past often needed several operations to replace the prosthesis with a larger one as they grew.

Chemotherapy

Clinical trials are being done to determine the best combinations of chemotherapy drugs, as well as the best time to give them. Newer chemotherapy drugs are being studied as well.

The lungs are the most common place for osteosarcoma to spread. Inhaled forms of some chemotherapy drugs (such as cisplatin) are being studied for patients whose cancer has spread to their lungs. Early results have been promising.

Other new forms of treatment

Chemotherapy drugs are often effective against osteosarcoma, but in some cases they don't work or the cancer becomes resistant to them over time. Researchers are studying newer types of drugs that attack osteosarcoma cells in different ways

Clinical trials are looking into ways to help the patient's immune system recognize and attack the osteosarcoma cells. An experimental immune-modulating drug called *muramyl tripeptide* (also known as MTP or mifamurtide) has been shown to help some patients when added to chemotherapy.

Doctors are also studying new medicines that target specific molecules on the cancer cells. These are known as targeted therapies. Some of these are man-made versions of immune system proteins, known as *monoclonal antibodies*. These antibodies attach to certain proteins on the cancer cell and help to stop the growth or kill the cancer cells. Examples now being studied include antibodies against the insulin-like growth factor receptor 1 (IGF-1R), a protein that may help cancer cells grow.

Other drugs that target bone cells called osteoclasts may also be useful against osteosarcoma. Bisphosphonates are a group of drugs that are already used to treat osteoporosis (bone thinning) and certain cancers that have spread to the bone. Some of these drugs, such as pamidronate and zoledronic acid, are now being studied for use in patients with osteosarcoma as well. Another drug that affects bones, known as saracatinib (AZD0530), is also under study.

Other new drugs being studied for use against osteosarcoma include:

- Drugs that affect a tumor's ability to make new blood vessels, such as bevacizumab (Avastin), cediranib, and sorafenib (Nexavar).
- Drugs that target the mTOR protein, such as temsirolimus (Torisel) and everolimus (Afinitor).

Additional resources for osteosarcoma

More information from your American Cancer Society

We have some related information that may also be helpful to you. These materials may be viewed on our Web site or ordered from our toll-free number at 1-800-227-2345.

After Diagnosis: A Guide for Patients and Families (also available in Spanish)

Childhood Cancer: Late Effects of Cancer Treatment

Children Diagnosed With Cancer: Dealing With Diagnosis (also available in Spanish)

Children Diagnosed With Cancer: Financial and Insurance Issues

Children Diagnosed With Cancer: Returning to School

Children Diagnosed With Cancer: Understanding the Health Care System (also available in Spanish)

Clinical Trials: What You Need to Know

Family and Medical Leave Act (FMLA)

Fertility and Cancer: What Are My Options?

Health Professionals Associated With Cancer Care

Nutrition for Children with Cancer (also available in Spanish)

Pediatric Cancer Centers (also available in Spanish)

Surgery

Understanding Chemotherapy: A Guide for Patients and Families (also available in Spanish)

Understanding Radiation Therapy: A Guide for Patients and Families

What Happened to You, Happened to Me (children's booklet)

When Your Brother or Sister Has Cancer (children's booklet)

When Your Child's Treatment Ends: A Guide for Families (booklet)

The following books are available from the American Cancer Society. Call us at 1-800-ACS-2345 to ask about costs or to place your order.

Because... Someone I Love Has Cancer

Cancer in the Family

Caregiving: A Step-By-Step Resource for Caring for the Person With Cancer at Home

Jacob Has Cancer: His Friends Want to Help (coloring book for a child with a friend who has cancer)

National organizations and Web sites*

In addition to the American Cancer Society, other sources of patient information and support include:

American Childhood Cancer Foundation (formerly Candlelighters)

Toll-free number: 1-800-366-2223 (1-800-366-CCCF)

Web site: www.candlelighters.org

Amputee Coalition of America

Toll-free number: 1-800-AMP-KNOW (1-800-267-5669)

Web site: www.amputee-coalition.org

CureSearch (National Childhood Cancer Foundation and Children's Oncology Group)

Toll-free number: 1-800-458-6223

Web site: www.curesearch.org

National Cancer Institute

Toll-free number: 1-800-422-6237 (1-800-4-CANCER)

Web site: www.cancer.gov

National Children's Cancer Society, Inc.

Toll-free number: 1-800-532-6459 (1-800-5-FAMILY)

Web site: www.children-cancer.org

Starlight Children's Foundation

Toll-free number: 1-800-315-2580

Web site: www.starlight.org

Teens Living with Cancer

Web site: www.teenslivingwithcancer.org

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

Other publications*

For adults

100 Questions & Answers About Your Child's Cancer, by William L. Carroll and Jessica Reisman. Jones and Bartlett Publishers, 2004.

Cancer & Self-Help: Bridging the Troubled Waters of Childhood Illness, by Mark A. Chester and Barbara K. Chesney. University of Wisconsin Press, 1995.

Care for Children and Adolescents with Cancer: Questions and Answers. National Cancer Institute. Available at: www.cancer.gov/cancertopics/factsheet/NCI/children-adolescents or call 1-800-332-8615.

Childhood Cancer: A Parent's Guide to Solid Tumor Cancers, by Honna Janes-Hodder and Nancy Keene. O'Reilly and Associates, 1999.

Childhood Cancer: A Handbook from St Jude Children's Research Hospital, by Grant Steen and Joseph Mirro (editors). Perseus Publishing, 2000.

Childhood Cancer Survivors: A Practical Guide to Your Future, by Nancy Keene, Wendy Hobbie, and Kathy Ruccione. O'Reilly and Associates, 2000.

Children with Cancer: A Comprehensive Reference Guide for Parents (2nd edition), by Jeanne Munn Bracken and Pruden Pruden. Oxford University Press, 2005.

Educating the Child With Cancer: A Guide for Parents and Teachers, edited by Nancy Keene. Candlelighters Childhood Cancer Foundation, 2003.

Living with Childhood Cancer: A Practical Guide to Help Families Cope, by Leigh A. Woznick and Carol D. Goodheart. American Psychological Association, 2002.

Surviving Childhood Cancer: A Guide for Families, by Margo Joan Fromer. New Harbinger Publications, 1998.

When Bad Things Happen to Good People, by Harold Kushner. G.K. Hall, 1982.

When Someone You Love Is Being Treated for Cancer. National Cancer Institute. Available at: www.cancer.gov/cancertopics/when-someone-you-love-is-treated, or call 1-800-332-8615.

Young People with Cancer: A Handbook for Parents. National Cancer Institute, 2003. Available at: www.cancer.gov/cancertopics/youngpeople, or call 1-800-332-8615.

Your Child in the Hospital: A Practical Guide for Parents (2nd edition), by Nancy Keene. O'Reilly & Associates. 1999. (Also available in Spanish.)

Books for teens and children

Although these books are intended for children, younger kids are helped more when an adult reads with and helps the child reflect about what different parts of the book mean to the child.

The Amazing Hannah, Look at Everything I Can Do! by Amy Klett. Candlelighters Childhood Cancer Foundation, 2002. For ages 1 to 6. (Also available in Spanish.)

Chemo, Crazyness and Comfort: My Book about Childhood Cancer by Nancy Keene. Candlelighters Childhood Cancer Foundation, 2002. Can be ordered from www.candlelighters.org. For ages 6 to 12.

Childhood Cancer Survivors: A Practical Guide to Your Future (2nd edition), by Kathy Ruccione, Nancy Keene, and Wendy Hobbie. Patient Centered Guides, 2006. For older teens.

Going to the Hospital, by Fred Rogers. Paperstar Book, 1997. For ages 4 to 8.

Life Isn't Always a Day at the Beach: A Book for All Children Whose Lives Are Affected by Cancer, by Pam Ganz. High-Five Publishing, 1996. Workbook for ages 6 to 10.

Little Tree: A Story for Children with Serious Medical Problems, by Joyce C. Mills. Magination Press, 2003. For ages 4 to 8.

Living Well With My Serious Illness, by Marge Heegaard. Fairview Press, 2003. For ages 8 to 12.

Me and My Marrow, by Karen Crowe. Published by Fujsawa Healthcare, 1999. For teens.

My Book for Kids with Cansur [sic], by Jason Gaes. Viking Penguin, 1998. For ages 4 to 8.

Oncology, Stupology...I Want to Go Home! by Marilyn K. Hershey. Butterfly Press, 1999. For ages 8 to 12. (Also available in Spanish.)

What About Me? When Brothers and Sisters Get Sick, by Allan Peterkin and Frances Middendorf. Magination Press, 1992. For brothers and sisters (ages 4 to 8) of a child with cancer.

When Someone Has a Very Serious Illness: Children Can Learn to Cope with Loss and Change, by Marge Heegaard. Woodland Press, 1991. For ages 6 to 12.

Why, Charlie Brown, Why? A Story About What Happens When a Friend Is Very Ill, by Charles M. Schultz. Ballantine Publishing Group, 1990. For ages 6 to 12.

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

References: Osteosarcoma detailed guide

American Cancer Society. *Cancer Facts & Figures 2012*. Atlanta, Ga. American Cancer Society 2012.

Bielack S, Carrle D, Casali PG, ESMO Guidelines Working Group. Osteosarcoma: ESMO clinical recommendations for diagnosis, treatment and follow-up. *Ann Oncol*. 2009;20 Suppl 4:137–139.

Bielack SS, Carrle D. State-of-the-art approach in selective curable tumors: Bone sarcoma. *Ann Oncol*. 2008;19 Suppl 7:vii155-vii160.

- Chou AJ, Bell MD, Mackinson C, et al. Phase Ib/IIa study of sustained release lipid inhalation targeting cisplatin by inhalation in the treatment of patients with relapsed/progressive osteosarcoma metastatic to the lung. *J Clin Oncol*. 2007;25(18s):9525.
- Damron TA, Ward WG, Stewart A. Osteosarcoma, chondrosarcoma, and Ewing's sarcoma: National Cancer Data Base Report. *Clin Orthop Relat Res*. 2007;459:40–47.
- Dome JS, Rodriguez-Galindo C, Spunt SL, Santana VM. Pediatric solid tumors. In: Abeloff MD, Armitage JO, Niederhuber JE, Kastan MB, McKenna WG, eds. *Abeloff's Clinical Oncology*. 4th ed. Philadelphia, Pa: Elsevier; 2008: 2075–2084.
- Gebhart MC, Springfield D, Neff J. Sarcomas of bone. In: Abeloff MD, Armitage JO, Niederhuber JE, Kastan MB, McKenna WG, eds. *Abeloff's Clinical Oncology*. 4th ed. Philadelphia, Pa: Elsevier; 2008: 1945–2008.
- Geller DS, Gorlick R. Osteosarcoma: A review of diagnosis, management, and treatment strategies. *Clin Adv Hematol Oncol*. 2010;8:705–718.
- Gorlick R, Bielack S, Teot L, Meyer J, Randall RL, Marina N. Osteosarcoma: Biology, diagnosis, treatment, and remaining challenges. In: Pizzo PA, Poplack DG, eds. *Principles and Practice of Pediatric Oncology*. 6th ed. Philadelphia Pa: Lippincott Williams & Wilkins; 2011:1015–1044.
- Hansen MF, Seton M, Merchant A. Osteosarcoma in Paget's disease of bone. *J Bone Miner Res*. 2006;21 Suppl 2:P58–63.
- Lewis DR, Ries LAG. Cancers of bone and joint. In: Ries LAG, Young JL, Keel GE, Eisner MP, Lin YD, Horner M-J, eds. *SEER Survival Monograph: Cancer Survival Among Adults: U.S. SEER Program, 1988-2001, Patient and Tumor Characteristics*. National Cancer Institute, SEER Program, NIH Pub. No. 07-6215, Bethesda, MD, 2007.
- Malawer MM, Helman LJ, O'Sullivan B. Sarcomas of bone. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. *DeVita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology*. 8th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2008: 1794–1833.
- Myers PA, Schwartz CL, Krailo MD, et al. Osteosarcoma: The addition of muramyl tripeptide to chemotherapy improves overall survival—a report from the Children's Oncology Group. *J Clin Oncol*. 2008;26:633–638.
- Nagarajan R, Neglia JP, Clohisy DR, Robison LL. Limb salvage and amputation in survivors of pediatric lower-extremity bone tumors: What are the long-term implications? *J Clin Oncol*. 2002;20:4493–4501.
- National Cancer Institute Physician Data Query (PDQ). Osteosarcoma/Malignant Fibrous Histiocytoma of Bone Treatment. 2010. Accessed at www.cancer.gov/cancertopics/pdq/treatment/osteosarcoma/healthprofessional on March 24, 2011.

National Comprehensive Cancer Network (NCCN). Practice Guidelines in Oncology: Bone Cancer. Version 2.2011. Accessed at www.nccn.org/professionals/physician_gls/PDF/bone_cancer.pdf on March 24, 2011.

Ries LAG, Smith MA, Gurney JG, Linet M, Tamra T, Young JL, Bunin GR (eds). *Cancer Incidence and Survival among Children and Adolescents: United States SEER Program 1975-1995*, National Cancer Institute, SEER Program. NIH Pub. No. 99-4649. Bethesda, MD, 1999.

Russell HV, Pappo AS, Nuchtern JG, et al. Solid tumors of childhood. In: DeVita VT, Lawrence TS, Rosenberg SA, eds. *DeVita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology*. 8th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2008: 2044–2050.

Yasko AW, Chow W, Haglund K. Bone sarcomas. In: Pazdur R, Wagman LD, Camphausen KA, Hoskins WJ, eds. *Cancer Management: A Multidisciplinary Approach*. 13th ed. UBM Medica; 2010: 607–620.

Last Medical Review: 6/29/2011

Last Revised: 1/17/2012

2011 Copyright American Cancer Society

For additional assistance please contact your American Cancer Society
1 · 800 · ACS-2345 or www.cancer.org