



Brain and Spinal Cord Tumors in Adults

What is cancer?

The body is made up of billions 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. But benign tumors also 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 brain and spinal cord tumors?

Brain tumors are masses of abnormal cells that have grown out of control. In most other parts of the body, it is very important to distinguish between benign (non-cancerous) and malignant (cancerous) tumors. Benign tumors in other parts of the body do not invade nearby tissues or spread to distant areas, so they are almost never life threatening. One of the main reasons cancers are so dangerous is because they can spread throughout the body.

Although brain tumors rarely spread to other parts of the body, most of them can spread through the brain tissue. Even so-called benign tumors can, as they grow, destroy and compress normal brain tissue, causing damage that is often disabling and sometimes fatal. For this reason, doctors usually speak of "brain tumors" rather than "brain cancers." The main concerns with brain tumors are how readily they spread through the rest of the brain or spinal cord and whether they can be removed and not come back.

Brain and spinal cord tumors are different in adults and children. They often form in different areas, develop from different cell types, and may have a different outlook and treatment. **This document refers only to adult tumors. Brain and spinal cord tumors in children are discussed in a separate document.**

To understand brain and spinal cord tumors, it helps to know about the normal structure and function of the central nervous system.

The central nervous system

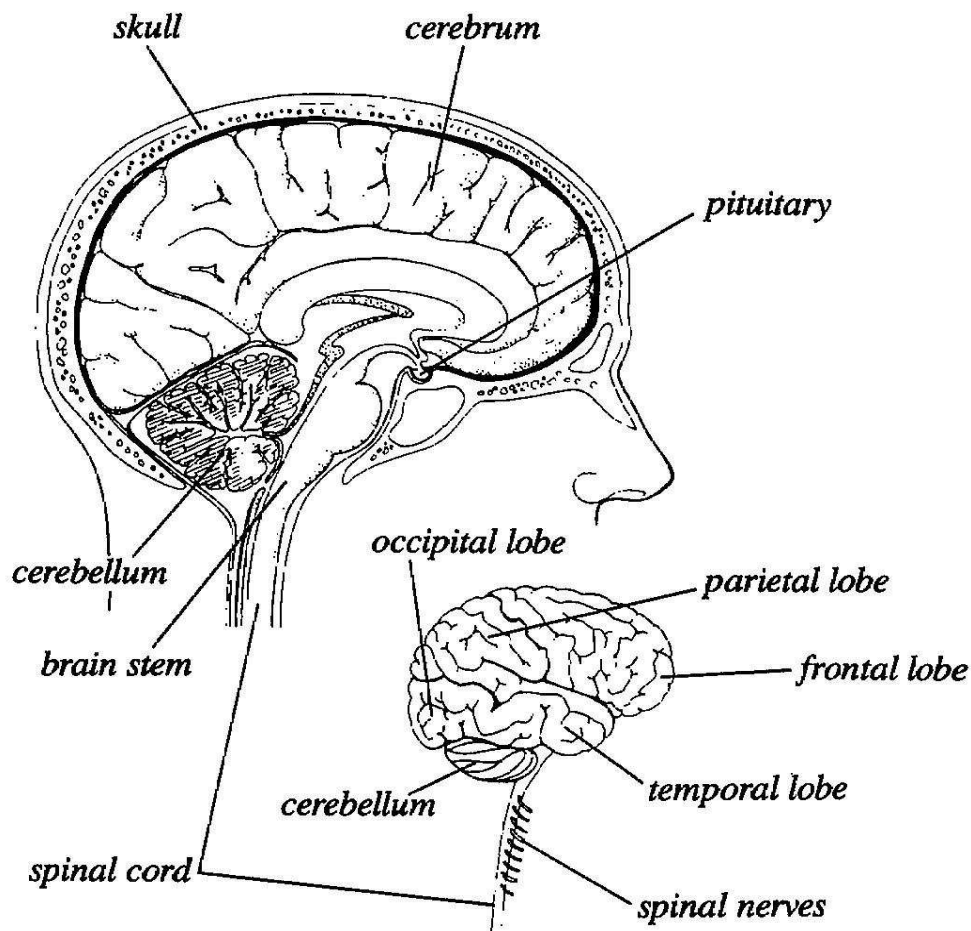
The central nervous system (CNS) is the medical name for the brain and spinal cord.

The brain is the center of thought, feeling, memory, speech, vision, hearing, movement, and much more. The spinal cord and special nerves in the head called cranial nerves help carry messages between the brain and the rest of the body. These messages tell our muscles how to move, transmit information gathered by our senses, and help coordinate the actions of our internal organs.

The brain is protected by the skull. Likewise, the spinal cord is protected by the bones (vertebrae) of the spinal column.

The brain and spinal cord are surrounded and cushioned by a special liquid, called *cerebrospinal fluid* (CSF). Cerebrospinal fluid is made by the choroid plexus, which is located in spaces within the brain called ventricles. The ventricles as well as the spaces around the brain and spinal cord are filled with CSF.

Parts of the brain and spinal cord



The main areas of the brain include the cerebrum, cerebellum, and brain stem. Each of these parts has a special function.

Cerebrum: The cerebrum is the large, outer part of the brain. It is made up of 2 hemispheres (halves) and controls reasoning, thought, emotion, and language. It is also responsible for planned muscle movements (throwing a ball, walking, chewing, etc.) and for taking in and interpreting sensory information such as vision, hearing, smell, touch, and pain.

The symptoms caused by a tumor in a cerebral hemisphere depend on the part of the hemisphere in which the tumor arises. Common symptoms include:

- Seizures
- Trouble speaking
- A change of mood such as depression
- A change in personality
- Weakness or paralysis of part of the body
- Changes in vision, hearing, or other sensations

Basal ganglia: The basal ganglia are structures deeper within the brain that help control our muscle movements. Tumors or other problems in this part of the brain typically cause weakness, but in rare cases can cause tremor, chorea (involuntary jerky movements), or athetosis (involuntary slow movements).

Cerebellum: The cerebellum lies under the cerebrum at the back part of the brain. It helps coordinate movement. Tumors of the cerebellum can cause problems with coordination in walking, trouble with fine movements of arms and legs, problems swallowing or synchronizing eye movements, and changes in rhythm of speech.

Brain stem: The brain stem is the lower part of the brain that connects to the spinal cord. It contains bundles of very long nerve fibers that carry signals controlling muscles and sensation or feeling between the cerebrum and the rest the body. Special centers in the brain stem also help control breathing and the beating of the heart. Also, most cranial nerves (which carry signals directly between the brain and the face, eyes, tongue, mouth, and some other areas) start in the brain stem.

Tumors in this critical area of the brain may cause weakness, stiff muscles, or problems with sensation, eye movement, hearing, facial movement, or swallowing. Double vision is a common early symptom of brain stem tumors, as are problems with coordination in walking. Because the brain stem is a small area that is so essential for life, it may not be possible to surgically remove tumors in this area.

Spinal cord: The spinal cord, like the brain stem, contains bundles of very long nerve fibers that carry signals controlling muscles, sensation or feeling, and bladder and bowel control. Spinal cord tumors may cause weakness, paralysis, or numbness. Because the spinal cord is such a narrow structure, tumors within it usually cause symptoms on both sides of the body (for example, weakness or numbness of both legs). This is different from brain tumors which usually affect only one side of the body.

Nerves that branch off the spinal cord to the arms arise in the neck (cervical spine). Nerves that branch off the spinal cord to the legs, bowel, and bladder arise in the back (thoracic and lumbar spine). Tumors of the spinal cord in the neck can cause symptoms in the arms and legs, as well as affect bowel and bladder function. Spinal cord tumors below the neck may only affect the legs and bowel and bladder function.

Cranial nerves: The cranial nerves are nerves that extend directly out of the base of the brain (as opposed to coming out of the spinal cord). Tumors starting in cranial nerves may cause vision problems, trouble swallowing, hearing loss in one or both ears, or facial paralysis, numbness, or pain.

Types of cells and body tissues in the brain and spinal cord

The brain and spinal cord have many kinds of tissues and cells, which can result in the development of different types of tumors. People with these tumors can have varying prognoses (outlooks) and may be treated differently.

Neurons (nerve cells): These are the most important cells in the brain. They carry electric signals that determine thought, memory, emotion, speech, muscle movement, and just about everything else that the brain and spinal cord do. Neurons send these signals through their nerve fibers (axons). Axons in the brain tend to be short, while those in the spinal cord can be as long as several feet. Unlike many other types of cells that can grow and divide to repair damage from injury or disease, neurons stop dividing about a year after birth (with a few exceptions). Neurons do not usually form tumors, but they are often damaged by tumors that start nearby.

Glial cells: Glial cells are the supporting cells of the brain. Most brain and spinal cord tumors develop from glial cells. These tumors are sometimes referred to as *gliomas*.

There are 3 types of glial cells – astrocytes, oligodendrocytes, and ependymal cells. A fourth cell type called microglia is part of the immune system and is not truly a glial cell.

- **Astrocytes** help support and nourish neurons. When the brain is injured, astrocytes form scar tissue that helps repair the damage. The main tumors starting in these cells are called *astrocytomas* or *glioblastomas*.
- **Oligodendrocytes** make myelin, a fatty substance that surrounds and insulates the nerve cell axons of the brain and spinal cord. This helps neurons send electric signals through the axons. Tumors starting in these cells are called *oligodendrogliomas*.
- **Ependymal cells** line the ventricles (fluid-filled areas) within the central part of the brain and form part of the pathway through which CSF flows. Tumors starting in these cells are called *ependymomas*.
- **Microglia** are the immune (infection fighting) cells of the central nervous system.

Neuroectodermal cells: These are primitive cells that are probably the remains of embryonic cells. They are found throughout the brain. The most common tumors that come from these cells develop in the cerebellum and are called *medulloblastomas*.

Meninges: These are layers of tissue that line and protect the brain and spinal cord. CSF travels through spaces formed by the meninges. The most common tumors that start in these tissues are called *meningiomas*.

Choroid plexus: The choroid plexus is the area of the brain within the ventricles that makes CSF, which nourishes and protects the brain.

Pituitary gland and hypothalamus: The pituitary is a small gland at the base of the brain. It is connected to a part of the brain called the *hypothalamus*. Both help regulate the activity of several other glands. For example, they control the amount of thyroid hormone made by the thyroid gland, the production and release of milk by the breasts, and the amount of male or female hormones made by the testicles or ovaries. They also make growth hormone, which stimulates body growth, and vasopressin, which regulates water balance by the kidneys.

The growth of tumors in or near the pituitary or hypothalamus, as well as surgery and/or radiation therapy in this area, can interfere with these functions. As a result, a person may have low levels of one or more hormones after treatment and may need to take hormones to correct any deficiencies.

Pineal gland: The pineal gland is not strictly part of the brain. It is, in fact, a small endocrine gland that sits between the cerebral hemispheres. It makes melatonin, a hormone that regulates sleep, in response to changes in light.

Blood-brain barrier: The small blood vessels (capillaries) in the brain and spinal cord create a very selective barrier between the blood and the tissues of the central nervous system. This normally helps maintain the brain's metabolic balance and keeps harmful toxins from getting into the brain. Unfortunately, it also keeps out most chemotherapy drugs that are used to kill cancer cells, which in some cases limits their usefulness.

Types of brain and spinal cord tumors

It's important to know the difference between tumors that start in the brain (primary brain tumors) and tumors that start in other organs, such as the lung or breast, and then spread to the brain (metastatic or secondary brain tumors). In adults, metastatic tumors to the brain are actually more common than primary brain tumors. These cancers are not treated the same way. For example, breast or lung cancers that spread to the brain are treated differently from cancers that start in the brain. **This document is only about primary brain and spinal cord tumors, not those that have spread from elsewhere in the body.**

Unlike cancers that start in other parts of the body, tumors that start in the brain or spinal cord rarely spread to distant organs. They cause damage because they can grow and spread into nearby areas, where they can destroy normal brain tissue. Still, tumors of the brain or spinal cord are rarely considered benign (non-cancerous). Unless they are completely removed or destroyed, most brain or spinal cord tumors will continue to grow and eventually be life-threatening.

Primary brain tumors can start in almost any type of tissue or cell in the brain or spinal cord. Some tumors contain a mixture of cell types. Tumors in different areas of the central nervous system may be treated differently and have a different prognosis (outlook).

Gliomas

Gliomas are not a specific type of cancer. Glioma is a general term for a group of tumors that start in glial cells. A number of tumors can be considered gliomas, including glioblastoma (also known as glioblastoma multiforme), astrocytomas, oligodendrogliomas, and ependymomas. About 3 out of 10 of all brain tumors are gliomas. Counting only malignant tumors, about 8 out of 10 are gliomas.

Astrocytomas: Most tumors that develop in the brain itself start in glial cells called astrocytes. These tumors are called astrocytomas. About 2 out of 10 brain tumors are astrocytomas.

Most astrocytomas can spread widely throughout the brain and blend with the normal brain tissue, which can make them very hard to remove by surgery. Sometimes they spread along the CSF pathways. It is very rare for them to spread outside of the brain or spinal cord.

Astrocytomas are often classified as low grade, intermediate grade, or high grade, based on how the cells look under the microscope.

- Low-grade astrocytomas tend to be slow growing.
- Intermediate-grade astrocytomas, or *anaplastic astrocytomas*, grow at a moderate rate.
- The highest-grade astrocytoma, known as *glioblastoma* (or glioblastoma multiforme), is the fastest growing. These tumors make up about two-thirds of astrocytomas and are the most common malignant brain tumors in adults.

Some low-grade types of astrocytomas called *non-infiltrating astrocytomas* tend to have a particularly good prognosis. These include juvenile pilocytic astrocytomas and subependymal giant cell astrocytomas. They are more common in children than in adults.

Oligodendrogliomas: These tumors start in brain cells called oligodendrocytes. Like astrocytomas, most of these can grow into (infiltrate) nearby brain tissue and cannot be completely removed by surgery. Oligodendrogliomas sometimes spread along the CSF pathways but rarely spread outside the brain or spinal cord. Very aggressive forms of these tumors are known as *anaplastic oligodendrogliomas*. Only about 2% of brain tumors are oligodendrogliomas.

Ependymomas: These tumors arise from ependymal cells, which line the ventricles. They can range from fairly low-grade (less aggressive) tumors to higher grade ones, which are called *anaplastic ependymomas*.

Ependymomas may spread along the CSF pathways but do not spread outside the brain or spinal cord. Ependymomas may block the exit of CSF from the ventricles, causing the ventricles to become very large – a condition called hydrocephalus.

Unlike astrocytomas and oligodendrogliomas, ependymomas usually do not grow into (infiltrate) normal brain tissue. As a result, some (but not all) ependymomas can be completely removed and cured by surgery. But because they can spread along ependymal surfaces and CSF pathways, treating them can sometimes be difficult. Spinal cord ependymomas have the greatest chance of surgical cure, but treatment can cause side effects related to nerve damage. Only about 2% of brain tumors are ependymomas.

Meningiomas

Meningiomas begin in the meninges, the layers of tissue that surround the outer part of the brain and spinal cord. Meningiomas account for about 1 out of 3 primary brain and spinal cord tumors. They are the most common brain tumors in adults (although strictly speaking, they are not actually "brain tumors").

The risk of these tumors increases with age. They occur about twice as often in women. In some cases these tumors run in families, especially in those with neurofibromatosis, a syndrome in which people develop many benign tumors of nerve tissue.

Meningiomas are often assigned a grade, based on how the cells look under the microscope.

- Grade I (benign) tumors have cells that look the most like normal cells. They make up about 80% of meningiomas. Most of these can be cured by surgery, but some grow very close to vital structures within the brain or cranial nerves and cannot be cured by surgery alone.
- Grade II (atypical) meningiomas have cells that look slightly more abnormal. About 15% to 20% of meningiomas are grade II. They are more likely to come back (recur) after surgery.
- Grade III (anaplastic) meningiomas have cells that look the most abnormal. They make up only about 1% to 3% of meningiomas. They tend to grow quickly and are the most likely to come back after treatment. Some may even spread to other parts of the body.

Medulloblastomas

Medulloblastomas are tumors that develop from neuroectodermal cells (primitive nerve cells) in the cerebellum. They are fast-growing tumors and often spread throughout the cerebrospinal fluid pathways, but they can be treated by radiation therapy and chemotherapy. Medulloblastomas occur much more often in children than in adults. They are part of a class of tumors called primitive neuroectodermal tumors (PNETs) that can also start in other parts of the central nervous system. They are discussed in more detail in our document, *Brain and Spinal Cord Tumors in Children*.

Gangliogliomas

A tumor containing both neurons and glial cells is called a ganglioglioma. These are very uncommon in adults and can usually be cured by surgery alone or surgery combined with radiation therapy.

Schwannomas (neurilemmomas)

Schwannomas arise from Schwann cells, which are the myelin-forming part of cranial nerves and other nerves. These are usually benign tumors. They can arise from any cranial nerve. When they form from the cranial nerve responsible for balance near the cerebellum they are called *vestibular schwannomas* or *acoustic neuromas*. They may also start in parts of spinal nerves outside of the spinal cord. Schwannomas make up about 9% of all CNS tumors.

Craniopharyngiomas

These slow-growing tumors start above the pituitary gland but below the brain itself. They may compress the pituitary gland and the hypothalamus, causing hormonal problems. Because they are very close to the optic nerves, they can also cause vision problems. Craniopharyngiomas are more common in children, but they are sometimes seen in older adults.

Other tumors that can start in or near the brain

Chordomas: These rare tumors start in the bone at the base of the skull or at the lower end of the spine. Chordomas don't start in the central nervous system, but they can injure the nearby area of the nervous system by compressing it. These tumors are treated with surgery if possible, often followed by radiation therapy, but they tend to come back in the same area after treatment, causing more and more damage. They usually do not spread to other organs. For more information on chordomas, see our document, *Bone Cancer*.

Non-Hodgkin lymphomas: Lymphomas are cancers that start in cells called lymphocytes (one of the main cell types of the immune system). Most lymphomas start in other parts of the body, but some may start in the CNS. These lymphomas are more common in people with immune system problems, such as those infected with HIV, the virus that causes AIDS. Because of new treatments for AIDS, CNS lymphomas have become less common in recent years. These lymphomas often grow quickly and can be hard to treat. Recent advances in chemotherapy, however, have improved the prognosis of people with these cancers. For more information on CNS lymphomas (including treatment), see our document, *Non-Hodgkin Lymphoma*.

What are the key statistics about brain and spinal cord tumors?

The American Cancer Society's most recent estimates for brain and spinal cord tumors in the United States are for 2012. They include both adults and children.

- About 22,910 malignant tumors of the brain or spinal cord (12,630 in males and 10,280 in females) will be diagnosed. These numbers would likely be much higher if benign tumors were also included.
- About 13,700 people (7,720 males and 5,980 females) will die from these tumors.

Overall, the chance that a person will develop a malignant tumor of the brain or spinal cord in his or her lifetime is less than 1% (about 1 in 150 for a man and 1 in 185 for a woman).

Survival rates vary widely, depending on the type of tumor. Survival rates for some of the more common types of brain and spinal cord tumors are discussed in the section, "Survival rates for selected brain and spinal cord tumors"

What are the risk factors for brain and spinal cord tumors?

A risk factor is anything that affects your chance of getting a disease such as cancer. Different cancers have different risk factors. For example, exposing skin to strong sunlight is a risk factor for skin cancer. Smoking is a risk factor for cancers of the lung, mouth, larynx (voice box), bladder, kidney, and several other organs.

But risk factors don't tell us everything. Having a risk factor, or even several, does not always mean that a person will get the disease, and many people get cancer without having any known risk factors.

Most brain tumors are not associated with any known risk factors and have no obvious cause, but there are a few factors that may raise the risk of brain tumors.

Radiation exposure

The best established environmental risk factor for brain tumors is radiation exposure, most commonly from some type of radiation therapy. For example, before the risks of radiation were recognized, children with ringworm of the scalp (a fungal infection) were sometimes treated with low-dose radiation therapy, which was later found to increase their risk of brain tumors as they got older.

Today, most radiation-induced brain tumors are caused by radiation to the head given to treat other cancers. This is most common in people who received radiation to the brain as children as part of their treatment for leukemia. These brain tumors usually develop around 10 to 15 years after the radiation.

These tumors are still fairly rare, but because of the increased risk (as well as the other side effects), radiation therapy to the head is only given after careful consideration of benefits and risks. For most patients with other cancers involving the brain or head, the benefits of radiation therapy far outweigh the risk of developing a brain tumor years later.

Family history

Most people with brain tumors do not have a family history of the disease, but in rare cases brain and spinal cord cancers run in families. In general, patients with familial cancer syndromes tend to have many tumors that first occur when they are young. Some of these families have well-defined disorders such as:

Neurofibromatosis type 1 (NF1)

This genetic disorder causes tumors to grow in the nervous system. People with this condition have higher risks of schwannomas, meningiomas, and certain types of gliomas, as well as neurofibromas (benign tumors of peripheral nerves). Changes in the NF1 gene cause this disorder. These changes are inherited from a parent in about half of all cases. In the other half, the NF1 gene changes occur before birth in people whose parents did not have this condition.

Neurofibromatosis type 2 (NF2)

This condition, which is much less common than NF1, is associated with vestibular schwannomas (acoustic neuromas) and, in some patients, meningiomas or spinal cord ependymomas. Changes in the NF2 gene are responsible for neurofibromatosis type 2. Like NF1, the gene changes are inherited in about half of cases or may occur before birth in children without a family history.

Tuberous sclerosis

People with this condition may have subependymal giant cell astrocytomas (low-grade astrocytomas that develop beneath the ependymal cells of the ventricles), along with benign tumors of the skin, heart, kidneys, and other organs. It is caused by changes in either the TSC1 or the TSC2 gene. These gene changes can be inherited from a parent, but in most cases they develop in people without a family history.

Von Hippel-Lindau disease

This condition is associated with an inherited tendency to develop benign or cancerous tumors in different parts of the body, including hemangioblastomas (blood vessel tumors) in the brain, spinal cord, or retina, as well as tumors of the inner ear, kidney, adrenal gland, and pancreas. It is caused by changes in the VHL gene. In most cases the gene changes are inherited, but in some cases the changes happen very early in life in people whose parents don't have them.

Li-Fraumeni syndrome

People with this condition are at higher risk for developing gliomas, along with certain other types of cancer. It is caused by changes in the p53 gene.

Other inherited conditions, including Gorlin syndrome, Turcot syndrome, and Cowden syndrome are also linked with increased risks of certain types of brain and spinal cord tumors. Other families may have genetic disorders that are not well recognized or that may even be unique to a particular family.

Immune system disorders

People with impaired immune systems have an increased risk of developing lymphomas of the brain or spinal cord. Lymphomas are cancers of lymphocytes, a type of white blood cell that fights disease. Lymphomas usually form in lymph nodes, which are small, bean-sized collections of lymphocytes found throughout the body. Primary lymphoma of the central nervous system is less common than lymphoma that develops outside the brain.

Deficiencies of the immune system may be congenital (present at birth), or they may be caused by treatments for other cancers, treatment to prevent rejection of transplanted organs, or the result of diseases such as the acquired immunodeficiency syndrome (AIDS).

Factors with uncertain, controversial, or unproven effects on brain tumor risk

Cell phone use

This has been the subject of a great deal of debate in recent years. Cell phones give off (emit) radiofrequency radiation, a form of energy on the electromagnetic spectrum between FM radio waves and those used in microwave ovens, radar, and satellite stations. Cell phones do not emit ionizing radiation, the type that damages DNA and can cause cancer. Still, there have been concerns that the phones, whose antennae are built-in and therefore are placed close to head when in use, might somehow raise the risk of brain tumors.

Some population-based studies have suggested a possible increased risk of brain tumors or of vestibular schwannomas with cell phone use, but most of the larger studies done to date have not found an increased risk, either overall or among specific types of tumors. Still, there are very few studies of long-term use (10 years or more), and cell phones haven't been around long enough to determine the possible risks of lifetime use. The same is true of any possible higher risks in children, who are increasingly using these phones. Cell phone technology also continues to change, and it's not clear how this might affect any risk.

These risks are being studied, but it will likely be many years before firm conclusions can be made. In the meantime, for people concerned about the possible risks, there are ways to lower exposure, such as using an earpiece to move the phone itself away from the head when used. For more information, see our document, *Cellular Phones*.

Other factors

Other environmental factors such as exposure to vinyl chloride (a chemical used to manufacture plastics), petroleum products, and certain other chemicals have been linked with increased risk in some studies but not in others. Exposure to aspartame (a sugar substitute), exposure to electromagnetic fields from power lines and transformers, and infection with certain viruses have been suggested as possible risk factors, but most researchers agree that there is no convincing evidence to link these factors to brain tumors. Research on these and other potential risk factors continues.

Do we know what causes brain and spinal cord tumors in adults?

The cause of most central nervous system tumors is not fully understood. But researchers have found some of the chemical changes that occur in normal brain cells that may lead them to form brain tumors.

Normal human cells grow and function based mainly on the information contained in each cell's chromosomes. Chromosomes are long molecules of DNA in each cell. Brain tumors, like other tumors, are caused by changes in a person's DNA. DNA is the chemical in each of our cells that makes up our genes — the instructions for how our cells function. We usually look like our parents because they are the source of our DNA. However, DNA affects more than how we look.

Some genes control when our cells grow, divide, and die. Certain genes that speed up cell 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. These gene changes can be inherited from a parent or, more likely, may happen during a person's lifetime as cells in the body divide to form 2 new cells.

In recent years, researchers have found the gene changes that cause some rare inherited syndromes (like neurofibromatosis, tuberous sclerosis, Li-Fraumeni syndrome, and von Hippel-Lindau syndrome) and increase the risk of developing some central nervous system tumors. For example, the Li-Fraumeni syndrome is caused by changes in the p53 tumor suppressor gene. Normally, this gene prevents cells with damaged DNA from growing. Changes in this gene increase the risk of developing brain tumors (particularly gliomas), as well as some other cancers.

In most cases, it is not known why people without inherited syndromes develop changes in cells of their central nervous system. Most risk factors for cancer somehow damage genes. For example, cigarette smoke is a risk factor for lung cancer and several other

cancers because it contains chemicals that can damage genes. The brain is relatively protected from cigarette smoke and other cancer-causing chemicals that we all breathe or eat, so these factors are not likely to play a major role in these cancers.

Normal cells usually require several different gene changes before they become cancerous. There are many kinds of brain tumors, each of which may have different sets of gene changes. A number of gene or chromosome changes have been found in different brain tumor types, but there are probably many others that have not yet been discovered.

Researchers now understand some of the gene changes that may occur in different types of brain tumors, but it's still not clear what might cause these changes. Some gene changes may be inherited, but most brain and spinal cord tumors are not the result of known inherited syndromes. Other gene changes may just be a random event that sometimes happens inside a cell, without having an external cause. Other than radiation, there are no known lifestyle-related or environmental causes of brain tumors, so it is important to remember that there is nothing these people could have done to prevent these cancers.

Can brain and spinal cord tumors in adults be prevented?

Most central nervous system tumors have not been linked with any known risk factors. As a result, most of these tumors cannot be prevented at this time.

Can brain and spinal cord tumors in adults be found early?

At this time there are no blood tests or other tests that can reliably detect brain tumors early enough to be useful as screening tests. (Screening is testing for cancer in people without any symptoms.) Without effective screening tests, most brain tumors are found only when they cause symptoms (see "How are brain and spinal cord tumors in adults diagnosed?").

In most cases, the patient's survival is determined by their age, the type of tumor, and its location, not by how early it is detected. But as with any disease, earlier detection and treatment is likely to be helpful.

For people diagnosed with certain inherited syndromes that put them at higher risk for brain tumors, such as neurofibromatosis or tuberous sclerosis, doctors may recommend starting frequent physical exams and other tests when the person is young. In some cases these tests may find tumors when they are still small. Not all tumors related to these syndromes may need to be treated right away, but finding them early may help doctors monitor them so that they can be treated quickly if they begin to grow or cause problems.

How are brain and spinal cord tumors in adults diagnosed?

Brain and spinal cord tumors are usually found because of signs or symptoms a person is having. If a tumor is suspected, tests will be needed to confirm the diagnosis.

Symptoms of brain and spinal cord tumors

Symptoms of brain or spinal cord tumors can be fairly general, or they may be more specific depending on where the tumor is located. Symptoms may occur gradually and become worse over time, or they can happen suddenly, such as with a seizure.

General symptoms

Tumors within any part of the brain may cause pressure to rise within the skull. This can be caused by growth of the tumor, swelling in the brain, or blockage of the flow of cerebrospinal fluid. Increased pressure can lead to general symptoms such as:

- Headache
- Nausea
- Vomiting
- Blurred vision
- Balance problems
- Personality or behavior changes
- Seizures
- Drowsiness or even coma

Headache is a common symptom of a brain tumor, occurring in about half of patients. (Of course, most headaches are not caused by tumors.)

About half of people with brain tumors will have seizures at some point. The type of seizure may depend on where the tumor is. Sometimes this is the first sign of a brain tumor, but fewer than 1 in 10 first seizures are caused by brain tumors.

Symptoms of tumors in different parts of the central nervous system

Tumors in different parts of the central nervous system can cause different symptoms. But these symptoms can be caused by any disease in that particular location in the brain — they do not always mean a brain tumor is present.

Brain and spinal cord tumors often cause problems with the specific functions of the region they develop in. For example:

- Tumors in the parts of the cerebrum (the large, outer part of the brain) that control movement or sensation may cause weakness or numbness of part of the body.

- Tumors in or near the parts of the cerebrum responsible for language may cause problems with speech or even understanding words.
- Tumors in the front part of the cerebrum can sometimes affect thinking and personality.
- Tumors in an area of the brain called the basal ganglia typically cause abnormal movements and an abnormal positioning of the body.
- If the tumor is in the cerebellum, where coordination is controlled, a person might have trouble with walking or other everyday functions, even eating.
- Tumors in the back part of the cerebrum, or around the pituitary gland, the optic nerve, or certain other cranial nerves can cause vision problems.
- Tumors in or near other cranial nerves might lead to loss of hearing, balance problems, weakness of some facial muscles, or trouble swallowing.
- Spinal cord tumors can cause numbness, weakness, or lack of coordination in the arms and/or legs, as well as bladder or bowel problems.

The brain also controls functions of some other organs, including the production of hormones, so many other symptoms can be caused by brain tumors that haven't been listed here.

Having one or more of the symptoms above does not mean that you definitely have a brain or spinal cord tumor. All of these symptoms can have other causes. Still, if you have symptoms that suggest that a brain or spinal cord tumor may be present, see your doctor so that the cause can be evaluated and treated, if needed.

Medical history and physical exam

If symptoms suggest you might have a CNS tumor, your doctor will take a complete medical history and do a neurologic exam to evaluate brain and spinal cord function. This special type of physical exam may be done by a general doctor. It tests reflexes, muscle strength, eye and mouth movement, coordination, alertness, and other functions.

If the results of the exam are abnormal, your doctor may refer you to a neurologist (a doctor specializing in nervous system diseases) or a neurosurgeon (a surgeon who specializes in nervous system diseases) to do a more detailed exam or for other tests.

Imaging tests

Your doctor may order one or more imaging tests. These tests use x-rays, strong magnets, or radioactive substances to create pictures of internal organs such as the brain and spinal cord. The pictures may be looked at by doctors specializing in this field (neurosurgeons, neurologists, and neuroradiologists) as well as by your doctor.

Magnetic resonance imaging (MRI) and computed tomography (CT) scans are used most often for brain diseases. MRI or CT scans will show a brain tumor, if one is present, in almost all cases, and can often tell the doctors exactly where the tumor is in the brain.

Magnetic resonance imaging (MRI) scan

MRI scans are very helpful in looking at the brain and spinal cord and are considered the best way to look for tumors in these areas. The images they provide are usually more detailed than those from CT scans (described below). But they do not image the bones of the skull as well as CT scans and therefore may not see the effects of tumors on the skull.

MRI scans use radio waves and strong magnets instead of x-rays. The energy from the radio waves is absorbed 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.

MRI scans can take a long time — often up to an hour. You have to lie inside a narrow tube, which can be confining and may upset people with a fear of enclosed spaces. Newer, open MRI machines may help with this, but they may provide less detailed images and can't be used in all cases. The machine also makes buzzing and clicking noises that may be disturbing. Some people might need medicine to help them relax for the test.

Magnetic resonance angiography: This special form of MRI (also known as MR angiography or MRA) may be done to look at the structure of the blood vessels in the brain. This can be very useful before surgery to help the surgeon plan an operation.

Magnetic resonance spectroscopy: This test (also known as MR spectroscopy or MRS) is like an MRI, except that the radio wave interactions with different atoms within the tissues are measured. MRS highlights some features of brain tumors that are not clearly seen by MRI. It generally produces graph-like results called *spectra* (although crude images can also be created). This may help narrow the possible type of tumor, but in most cases a biopsy of the tumor is still needed to be sure. MRS can also be used after treatment to help determine if an abnormal area is remaining tumor or if it is more likely to be scar tissue.

Magnetic resonance perfusion: For this test, also known as perfusion MRI, a contrast dye is injected quickly into a vein. A special type of MR image is then obtained to look at the amount of blood going through different parts of the brain and tumor. Tumors need a bigger blood supply than normal areas of the brain. The faster a tumor is growing, the more blood it needs.

Perfusion MRI can give doctors an idea of how quickly a tumor is growing or help show them the best place to take a biopsy. It can also be used after treatment to help determine if an abnormal area is remaining tumor or if it is more likely to be scar tissue.

Functional MRI (fMRI): This newer type of MRI looks for tiny chemical changes in an active part of the brain. It can be used to determine what part of the brain handles a

function such as speech, thought, sensation, or movement. Doctors can use this to determine which parts of the brain to avoid when planning surgery or radiation therapy.

This test is similar to a standard MRI, except that you will be asked to perform specific tasks (such as answering simple questions or moving your fingers) while the scans are being done.

Computed tomography (CT) scan

The CT scan is an x-ray test that produces detailed cross-sectional images of your brain and spinal cord (or other parts of the body). Instead of taking one picture, like a regular x-ray, a CT scanner takes many pictures as it rotates around you while you lie on a table. A computer then combines these pictures into images of slices of the body. Unlike a regular x-ray, a CT scan creates detailed images of the soft tissues in the body.

Before the scan, you may get an injection of a contrast dye through an IV (intravenous) line. This helps better outline any tumors that are present. The contrast may cause some flushing (a feeling of warmth, especially in the face). Some people are allergic and get hives. Rarely, people have more serious reactions like trouble breathing or low blood pressure. Be sure to tell the doctor if you have any allergies or if you 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 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 surrounds the table. Some people feel a bit confined by the ring they have to lie in while the pictures are being taken. *Spiral CT* (also known as *helical CT*) is now used in many medical centers. This type of CT scan uses a faster machine that reduces the dose of radiation and yields more detailed pictures.

CT scans are not used as often as MRI scans, but they do have features that make them useful. They may be used in some cases if MRI is not an option (such as in people who are very overweight or people who have a fear of enclosed spaces). CT scans also provide greater detail of the bone structures near the tumor.

CT angiography: For this test, you are injected with a contrast material through an IV line while you are in the CT scanner. The scan creates detailed images of the blood vessels in the brain, which can help doctors plan surgery. CT angiography can provide better details of the blood vessels in and around a tumor than MR angiography in some cases.

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 larger amounts of the sugar than most other cells. 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

can provide helpful information about whether abnormal areas seen on other tests (such as MRIs) are likely to be cancerous or not.

This test is also useful after treatment, as it can help tell whether the tumor cells have been killed. (Dead cells do not use glucose.) Abnormal areas may still show up on an MRI scan. PET scans can help determine if the abnormal area is remaining tumor or if it is more likely to just be scar tissue.

Chest x-ray

This is a plain x-ray of your chest, which can be done in a doctor's office, in an outpatient radiology center, or in a hospital. It may be done once a tumor is found in the brain, because in adults most tumors in the brain have actually started in another organ (most often the lung) and spread to the brain.

Angiogram

For this test, a special dye is injected into blood vessels that lead to the region of the tumor, and the area is then viewed with x-rays. This helps doctors look at the blood supply of a tumor.

This test is not done much any more, as it has largely been replaced by other tests that can look at blood vessels, such as computerized tomographic angiography (CTA) or magnetic resonance angiography (MRA).

In very selected cases the angiogram may be used as part of the treatment for certain brain tumors. It is done as a first step of a procedure called *embolization*, in which the radiologist injects tiny particles into the blood vessels feeding the tumor to block them and make it easier to remove the tumor.

Brain or spinal cord tumor biopsy

Imaging tests such as MRI and CT scans may show an abnormal area that is likely to be a brain tumor. But in most cases these scans cannot give a definite diagnosis of brain cancer. This can only be done by removing some of the tumor tissue, which is called a biopsy.

Once the tissue is removed, it is looked at under a microscope by a pathologist (a doctor specializing in diagnosis of diseases by lab tests) or a neuropathologist (a pathologist specializing in nervous system diseases). The pathologist determines if the tumor is benign or malignant (cancerous) and exactly what type of tumor it is.

Sometimes, the appearance of an astrocytoma on an MRI scan is so characteristic that a biopsy is not needed, especially when the tumor is located in a part of the brain that would make it hard to biopsy (such as the brain stem). In rare cases a PET scan or MR spectroscopy may give enough information so that a biopsy is not needed.

There are 2 main types of biopsies for brain tumors.

Stereotactic (needle) biopsy

This type of biopsy may be used when the risks of surgery might be too high (such as with some tumors in vital areas, those deep within the brain, or other tumors that probably can't be treated with surgery) but a sample is still needed to make a diagnosis.

The patient may be asleep (under general anesthesia) or awake during the biopsy. If the patient is awake, the neurosurgeon injects a local anesthetic into areas of skin above the skull to numb them. A rigid frame may then be fixed onto the head. This helps make sure the surgeon is targeting the tumor precisely. A cut (incision) is made in the scalp and a small hole is drilled in the skull. An MRI or CT scan is often used along with the frame to help the neurosurgeon guide a hollow needle into the tumor and remove small pieces of tissue. Another approach is to attach markers to the scalp, get an MRI or CT, and then use an image-guidance system to direct the needle into the tumor. This still requires that an incision be made and small hole be drilled into the skull.

The removed tissue is sent to a pathologist, who looks at it under a microscope to determine what type of tumor it is. This information is very important in determining the prognosis (outlook) and the best course of treatment.

Surgical or open biopsy (craniotomy)

If the tumor can be treated with surgery based on the imaging tests, the neurosurgeon may not do a needle biopsy. Instead, he or she may do an operation called a *craniotomy* (described in the "Surgery" section) to remove all or most of the tumor. (Removing most of the tumor is known as *debulking*.)

Small samples of the tumor are looked at right away by the pathologist while the patient is still in the operating room, to obtain a preliminary diagnosis. This can help guide treatment, including whether further surgery should be done at that time. A final diagnosis is made a few days later in most cases.

Lumbar puncture (spinal tap)

This test is used to look for cancer cells in the cerebrospinal fluid (CSF), which is the liquid that surrounds the brain and spinal cord. For this test, you lay on your side on a bed or exam table with your knees up near your chest. The doctor first numbs an area in the lower part of the back near the spine. A small, hollow needle is then placed between the bones of the spine to withdraw some of the fluid.

This fluid is sent to a lab to be looked at under a microscope for cancer cells. Other tests may be done on the fluid as well.

Lumbar punctures are usually very safe, but doctors have to make sure the test does not result in a dramatic change in pressure in the fluid, which could possibly cause serious problems. For this reason, imaging tests such as CT or MRI scans are done beforehand.

Except for lesions in the pineal region, lumbar punctures usually aren't done to diagnose brain tumors, but they may be done after a diagnosis is made for certain types of brain tumors that can commonly spread by way of the CSF (such as ependymomas). They are particularly important in people with suspected brain lymphomas because often the lymphoma cells spread into the spinal fluid.

Blood and urine tests

These lab tests rarely are part of the actual diagnosis of brain and spinal cord tumors, but they may be done to check how well the liver, kidneys, and some other organs are working. This is especially important before any planned surgery. If you are getting chemotherapy, blood tests will be done routinely to check blood counts and to see if the treatment is affecting other parts of the body.

How are brain and spinal cord tumors in adults staged?

Staging is the process of gathering information from exams and imaging tests to find out how far a cancer has spread. A staging system is a standardized way for the cancer care team to describe the extent of the cancer spread. For most types of cancer, the stage (extent) of the cancer is one of the most important factors in selecting treatment options and in determining the outlook (prognosis).

But tumors of the central nervous system (CNS) differ in some important ways from cancers in other parts of the body. The most deadly aspect of other cancers is their ability to spread throughout the body. Tumors starting in the brain or spinal cord can spread to other parts of the CNS, but they almost never spread to other organs. The most dangerous aspect of these tumors is that they can interfere with essential functions of the brain.

Because tumors in the brain or spinal cord almost never spread to other parts of the body, there is no formal staging system for them. Some of the most important factors that help determine outlook include:

- The person's age
- The person's functional level (whether the tumor has started to interfere with normal brain functions)
- The type of tumor (such as astrocytoma, ependymoma, etc.)
- The grade of the tumor (how quickly the tumor is likely to grow, based on how the cells look under a microscope)
- The size and location of the tumor
- How much of the tumor can be removed by surgery (if it can be done)

- Whether or not the tumor has spread through the cerebrospinal fluid (CSF) to other parts of the brain and/or spinal cord
- Whether or not tumor cells have spread beyond the central nervous system

How are brain and spinal cord tumors in adults 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.

The next few sections describe the various types of treatments used for brain and spinal cord tumors. This is followed by a description of the most common approaches used based on the type of tumor.

General comments about treatment

Brain and spinal cord tumors can often be difficult to treat and may require care from a team of several different doctors. This team is often led by a neurosurgeon, a doctor who uses surgery to treat brain and nervous system tumors. Other doctors on the team may include:

- Neurologist: a doctor who diagnoses and treats brain and nervous system diseases
- Radiation oncologist: a doctor who uses radiation to treat cancer
- Medical oncologist: a doctor who uses chemotherapy and other medicines to treat cancers
- Endocrinologist: a doctor who treats diseases in glands that secrete hormones

Many other specialists may be involved in your care as well, including nurse practitioners, nurses, psychologists, social workers, rehabilitation specialists, and other health professionals.

Several types of treatment may be used to treat central nervous system (CNS) tumors, including:

- Surgery
- Radiation therapy
- Chemotherapy

- Targeted therapy
- Other types of drugs

Treatment is based on the type of tumor and other factors, and in many cases a combination of treatments is used. Doctors plan each person's treatment individually to give them the best chance of treating the cancer effectively while limiting the possible long-term side effects.

Surgery for brain and spinal cord tumors

For brain tumors, surgery may be done for different reasons:

- To get a biopsy sample to determine the type of tumor
- To remove as much of the tumor as possible
- To help prevent or treat possible complications from the tumor

Before surgery, be sure you understand what the goal of the surgery is, as well as the potential benefits and risks.

Surgery to remove the tumor

In most cases, the first step in brain tumor treatment is for the neurosurgeon to remove as much of the tumor as is safe without affecting normal brain function.

Surgery alone or combined with radiation therapy may cure many tumors, including some low-grade astrocytomas, ependymomas, craniopharyngiomas, gangliogliomas, and meningiomas.

Tumors that tend to spread diffusely into nearby brain tissue such as anaplastic astrocytomas or glioblastomas are not cured by surgery. But surgery can reduce the amount of tumor that needs to be treated by radiation or chemotherapy, which can help these treatments work better. This may help prolong life even if all of the tumor can't be removed.

Surgery may also improve some of the symptoms caused by brain tumors, particularly those caused by a buildup of pressure within the skull. These can include headaches, nausea, vomiting, and blurred vision. Surgery may also be used to help control seizures.

Surgery may not be a good option in some cases, such as if the tumor is deep within the brain, if it is in a part of the brain that can't be removed, such as the brain stem, or if a person is unable to tolerate a major operation for other health reasons.

Surgery is not very effective against some types of brain tumors, such as lymphomas, although it may be used to get a biopsy for diagnosis.

Craniotomy: A craniotomy is a surgical opening in the skull. This is the main type of operation for treatment of brain tumors. For this operation, the person may either be under general anesthesia (in a deep sleep) or may be awake for at least part of the

procedure (with the surgical area numbered) if brain function needs to be assessed during the operation.

Part of the head may need to be shaved. The neurosurgeon first makes an incision in the scalp, and the skin is folded back. The surgeon then uses a special type of drill to remove the piece of the skull over the tumor.

The craniotomy is typically large enough for the surgeon to insert several instruments and view the parts of the brain needed to operate safely. The surgeon makes a small incision into the brain itself to reach the tumor. The surgeon may use MRI, CT, or ultrasound images to help locate the tumor and its edges.

The surgeon can remove the tumor in several ways depending on how hard or soft it is, and whether it has many or just a few blood vessels. One way is to cut it out with a scalpel or special scissors. Some lesions are soft and can be removed with simple suction devices. In other cases, a probe attached to an ultrasonic generator may be placed into the tumor to break it up and liquefy it. A small vacuum device is then used to suck it out.

Many devices can help the surgeon see the tumor and surrounding brain tissue. The surgeon often operates while looking at the brain through a microscope. As mentioned above, image guidance with MRI, CT, or ultrasound can be used to map the area of tumors buried deep in the brain. In some cases, the surgeon may use intraoperative imaging, in which MRI (or other) images are taken at different times during the operation to show the location of any remaining tumor. This can allow some brain tumors to be resected more safely and extensively.

The surgeon tries to remove as much of the tumor as possible without affecting important brain tissue or leaving the patient disabled in any way. The surgeon can detect the function of the brain by electrically stimulating parts of the brain in and around the tumor and monitoring the response. This will show if these areas control an important function. Using this technique, known as *intraoperative cortical stimulation*, surgeons can lower the risk of removing vital parts of the brain. Alternatively, a particular function of the brain can be located prior to surgery with a technique called functional MRI. This information can be used to identify and preserve that region during the operation.

In most cases the removed piece of bone is put back in place and fastened to the skull with metal screws and plates, wires, or special stitches. Healing usually takes several weeks. Recovery time in the hospital is usually 4 to 6 days, although this may vary according to the size and location of the tumor and the patient's general health.

Surgery to place a shunt or ventricular access catheter

Blockage of the cerebrospinal fluid (CSF) flow by a tumor can increase pressure inside the skull. This can cause symptoms like headaches, nausea, and drowsiness, and may even be life-threatening.

To drain excess CSF and lower the pressure, the neurosurgeon may put in a silicone tube called a *shunt* (sometimes referred to as a *ventriculoperitoneal* or *VP shunt*). One end of the shunt is placed in a ventricle of the brain (an area filled with CSF) and the other end

is placed in the abdomen or, less often, the heart or other areas. The tube runs under the skin of the neck and chest. The flow of CSF is controlled by a valve placed along the tubing.

Shunts may be temporary or permanent. They may be placed before or after the surgery to remove the tumor. Shunt placement is normally a straightforward procedure that takes about an hour. As with any operation, complications may develop, such as bleeding or infection. Sometimes shunts get clogged and need to be replaced. The hospital stay after shunt procedures is typically 1 to 3 days, depending on the reason it is placed and the patient's health.

Surgery may also be used to insert a ventricular access catheter, such as an Ommaya reservoir, to help deliver chemotherapy directly into the CSF. A small incision is made in the scalp, and a small hole is drilled in the skull. A flexible tube is then threaded through the hole until the open end of the tube is in a ventricle, where it reaches the CSF. The other end, which has a dome-shaped reservoir, remains just under the scalp. After the operation, doctors and nurses can use a thin needle to give chemotherapy drugs through the reservoir or to remove CSF from the ventricle for testing.

Possible risks and side effects of surgery

Surgery on the brain or spinal cord is a serious operation, and surgeons are very careful to try to limit any problems either during or after surgery. Complications during or after surgery such as bleeding, infections, or reactions to anesthesia are rare, but they can happen.

A major concern after surgery is swelling in the brain. Drugs called corticosteroids are typically given for several days after surgery to help lessen this risk.

One of the biggest concerns when removing brain tumors is the possible loss of brain function afterward, which is why doctors are very careful to remove only as much tissue as is safely possible.

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

Radiation therapy for brain and spinal cord tumors

Radiation therapy uses high-energy rays or particles to kill cancer cells. This type of treatment is given by a doctor called a *radiation oncologist*. Radiation therapy may be used in different situations:

- After surgery to try to kill any remaining tumor cells
- As the main treatment if surgical removal is not a good option and medicines are not effective
- To help prevent or relieve symptoms, especially for spinal cord tumors

Types of radiation therapy

In most cases, the radiation is focused precisely on the tumor from a source outside the body. This is called *external beam radiation therapy (EBRT)*. This type of radiation therapy is much like getting an x-ray, but the dose of radiation is much higher.

Before your treatments start, the radiation team will measure carefully to determine the correct angles for aiming the radiation beams and the proper dose of radiation. In most cases, the total dose of radiation is divided into daily fractions (usually given Monday through Friday) over several weeks. At each session, you lie on a special table while a machine delivers the radiation from a precise angle. The treatment is not painful. Each session lasts about 15 to 30 minutes. Much of that time is spent making sure the radiation is aimed correctly. The actual treatment time each day is much shorter.

High doses of radiation therapy can damage normal brain tissue, so doctors try to deliver high doses of radiation to the tumor with the lowest possible dose to normal surrounding brain areas. Several newer techniques help doctors focus the radiation more precisely:

Three-dimensional conformal radiation therapy (3D-CRT): 3D-CRT uses the results of imaging tests such as MRI and special computers to map the location of the tumor precisely. Several radiation beams are then shaped and aimed at the tumor from different directions. Each beam alone is fairly weak, which makes it less likely to damage normal tissues, but the beams converge at the tumor to give a higher dose of radiation there.

Intensity modulated radiation therapy (IMRT): IMRT is an advanced form of 3D therapy. It uses a computer-driven machine that actually moves around the patient as it delivers radiation. In addition to shaping the beams and aiming them at the tumor from several angles, the intensity (strength) of the beams can be adjusted to minimize the dose reaching the most sensitive normal tissues. This may let the doctor deliver a higher dose to the tumor. Many major hospitals and cancer centers now use IMRT.

Conformal proton beam radiation therapy: Proton beam therapy is related to 3D-CRT and uses a similar approach. But instead of using x-rays, it focuses proton beams on the tumor. Protons are positive parts of atoms. Unlike x-rays, which release energy both before and after they hit their target, protons cause little damage to tissues they pass through and then release their energy after traveling a certain distance. Doctors can use this property to deliver more radiation to the tumor and do less damage to nearby normal tissues. This approach may be more helpful for brain tumors that have distinct edges, but it is not clear if this approach will be useful with tumors that are infiltrative or mixed with normal brain tissue. The machines needed to make protons are expensive, and there are only a handful of proton beam centers in the United States at this time.

Stereotactic radiosurgery/stereotactic radiotherapy: This type of treatment delivers a large, precise radiation dose to the tumor area in a single session (radiosurgery) or in a few sessions (radiotherapy). (There is no actual surgery involved in this treatment.) It may be useful for some tumors in parts of the brain or spinal cord that can't be treated with surgery or when a patient's health does not permit surgery.

First, a head frame is attached to the skull to help precisely aim the radiation beams. Once the exact location of the tumor is known from CT or MRI scans, radiation may be delivered in one of two ways.

In one approach, radiation beams from a machine are focused at the tumor from hundreds of different angles for a short period of time. An example of such a machine is the Gamma Knife.

Another approach uses a movable linear accelerator (a machine that creates radiation) that is controlled by a computer. Instead of delivering many beams at once, this machine moves around the head to deliver radiation to the tumor from different angles. Several machines with names such as X-Knife, CyberKnife, and Clinac, deliver stereotactic radiosurgery in this way.

Stereotactic radiosurgery typically delivers the whole radiation dose in a single session, though it may be repeated if needed. Sometimes doctors give the radiation in several treatments to deliver the same or a slightly higher dose. This is called *fractionated radiosurgery* or *stereotactic radiotherapy*.

Brachytherapy (interstitial radiotherapy): Unlike the external radiation approaches above, brachytherapy involves inserting radioactive material directly into or near the tumor. The radiation given off travels a very short distance, so it affects only the tumor. This technique is most often used along with external radiation. It provides a high dose of radiation at the tumor site, while the external radiation treats nearby areas with a lower dose.

Whole brain and spinal cord radiation therapy (craniospinal radiation): If tests like an MRI scan or lumbar puncture find the tumor has spread along the spinal cord meninges, or into the surrounding fluid, then radiation may be given to the whole brain and spinal cord. Some tumors such as ependymomas and medulloblastomas are more likely to spread this way and often require craniospinal radiation.

Possible side effects of radiation therapy

Radiation is more harmful to tumor cells than it is to normal cells. Still, normal brain tissue is also damaged by radiation.

Some people may become irritable and fatigued during the course of radiation therapy. Nausea, vomiting, and headaches are also possible but are uncommon. Sometimes dexamethasone (Decadron), a cortisone-like drug, can help relieve these symptoms.

A person may lose some brain function if large areas of the brain receive radiation. Problems can include memory loss, personality changes, and trouble concentrating. There may also be other symptoms depending on the area of brain treated and how much radiation was given. These risks must be balanced against the risks of not using radiation and having less control of the tumor.

Rarely after radiation therapy, a large mass of dead (necrotic) tissue forms at the site of the tumor. This occurs months to years after radiation is given and is called *radiation*

necrosis. Though this can often be controlled with corticosteroid drugs, surgery may be needed to remove the necrotic tissue in some instances.

Radiation can damage genes in normal cells. As a result, there is a small risk of developing a second cancer in an area that got radiation — for example, a meningioma of the coverings of the brain, another brain tumor, or less likely a bone cancer in the skull. If this does occur, it is usually many years after the radiation is given. This small risk should not prevent those who need radiation from getting treatment.

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

Chemotherapy for brain and spinal cord tumors

Chemotherapy (also known as "chemo") uses anti-cancer drugs that are usually given into a vein (IV) or taken by mouth. These drugs enter the bloodstream and reach almost all areas of the body. However, because of the blood-brain barrier (see “What are brain and spinal cord tumors in adults?”), many chemotherapy drugs are not able to enter the brain and reach tumor cells.

For some brain tumors, the drugs may be given directly into the cerebrospinal fluid (CSF), either in the brain or into the spinal canal below the spinal cord. To help with this, a thin tube, known as a ventricular access catheter, may be inserted through a small hole in the skull and into a ventricle of the brain during a minor operation (see the "Surgery" section).

In general, chemotherapy is used for higher grade tumors. Some types of brain tumors, such as medulloblastoma and lymphoma, tend to respond better to chemotherapy.

Chemotherapy is most often used along with other types of treatment such as surgery and/or radiation therapy. Chemotherapy may also be used by itself, especially for more advanced tumors or for tumors that have come back after other types of treatment.

Some of the chemotherapy drugs that may be used to treat brain tumors include:

- Carmustine (BCNU)
- Lomustine (CCNU)
- Temozolomide
- Carboplatin
- Cisplatin
- Etoposide
- Irinotecan
- Methotrexate
- Procarbazine
- Vincristine

These drugs may be used alone or in various combinations, depending on the type of brain tumor. Doctors give chemotherapy in cycles, with each period of treatment followed by a rest period to give the body time to recover. Each chemotherapy cycle typically lasts for a few weeks.

Carmustine (Gliadel®) wafers

These dissolvable wafers contain the chemotherapy drug carmustine (BCNU). During a craniotomy, they can be placed directly on or next to parts of brain tumors that can't be removed. Unlike IV or oral chemotherapy that reaches all areas of the body, this type of therapy increases the drug concentration at the tumor site with minimal side effects in other parts of the body.

Possible side effects of chemotherapy

Chemotherapy drugs attack cells that are dividing quickly, which is why they often work against cancer cells. But other cells, 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.

The side effects of chemotherapy depend on the type of drugs, the amount taken, and the length of treatment. Possible side effects can include:

- Hair loss
- Mouth sores
- Loss of appetite
- Nausea and vomiting
- Diarrhea
- Increased chance of infections (due to low white blood cell counts)
- Easy bruising or bleeding (due to low blood platelet counts)
- Fatigue (due to low red blood cell counts, changes in metabolism, or other factors)

Fortunately, some of the most effective drugs against brain tumors tend to have fewer of these side effects than other common chemotherapy drugs, but they are still possible. These side effects are usually short-term and go away after treatment is finished. There are often ways to lessen these side effects. For example, drugs can be given to help prevent or reduce nausea and vomiting.

Along with the risks above, some chemotherapy drugs can cause other, less common side effects. For example, cisplatin and carboplatin can also cause kidney damage and hearing loss. Your doctor will check your kidney function and hearing if you are given these drugs. Some of these side effects may persist after treatment is stopped.

You should report any side effects you notice while getting chemotherapy to your medical team so that you can be treated promptly. In some cases, the doses of the chemotherapy drugs may need to be reduced or treatment may need to be delayed or stopped to prevent the effects from getting worse.

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

Targeted therapy for brain and spinal cord tumors

As researchers have learned more about the gene changes that cause cancer or help cancer cells grow, they have been able to develop newer drugs that specifically target these changes. These targeted drugs work differently from standard chemotherapy drugs. They often have different (and less severe) side effects.

Bevacizumab (Avastin): Bevacizumab is a manmade version of an immune system protein called a monoclonal antibody. This antibody targets vascular endothelial growth factor (VEGF), a protein that helps tumors form new blood vessels to get nutrients (a process known as angiogenesis). Tumors need new blood vessels in order to grow.

Bevacizumab is given by intravenous (IV) infusion, usually once every 2 weeks. Some early studies have shown it might help shrink certain brain tumors, especially glioblastomas, but it is not yet clear if it can help people live longer.

More common side effects include high blood pressure, tiredness, bleeding, low white blood cell counts, headaches, mouth sores, loss of appetite, and diarrhea. Rare but possibly serious side effects include blood clots, internal bleeding, heart problems, holes (perforations) in the intestines, and slow wound healing.

Everolimus (Afinitor): This drug works by blocking a cell protein known as mTOR, which normally promotes cell growth and division. For subependymal giant cell astrocytomas that can't be removed completely by surgery, it may shrink the tumor or slow its growth for some time.

Everolimus is taken as a pill once a day. Common side effects of this drug include mouth sores, increased risk of infections, nausea, loss of appetite, diarrhea, skin rash, feeling tired or weak, fluid buildup (usually in the legs), and increases in blood sugar and cholesterol levels. A less common but serious side effect is damage to the lungs, which can cause shortness of breath or other problems.

Many other targeted therapies are now being developed and studied in clinical trials.

Other drug treatments for brain and spinal cord tumors

Some drugs commonly used in people with brain tumors do not treat the tumors directly, but they may help to lessen symptoms from the tumor or its treatment.

Corticosteroids

Cortisone-like drugs such as dexamethasone (Decadron) are often given to reduce swelling around brain tumors. This may help relieve headaches and other symptoms.

Anti-seizure drugs (anti-epileptics)

Drugs may also be prescribed to lower the chance of seizures, which may happen in people with brain tumors. Different anti-seizure drugs may be used depending on a patient's circumstances. Because these drugs can often interfere with other drugs, such as chemotherapy, they are not usually given unless the tumor has caused seizures.

Clinical trials for brain and spinal cord tumors

You may have had to make a lot of decisions since you've been told you have cancer. One of the most important decisions you will make is choosing which treatment is best for you. You may have heard about clinical trials being done for your 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. They are done to get a closer look at promising new treatments or procedures.

If you would like to take part in a clinical trial, 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's 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.

There are requirements you must meet to take part in any clinical trial. If you do qualify for a clinical trial, it is up to you whether or not to enter (enroll in) it.

Clinical trials are one way to get state-of-the-art cancer treatment. 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 brain and spinal cord tumors

When you have cancer you are likely to hear about ways to treat your cancer or relieve symptoms that your doctor hasn't mentioned. Everyone from friends and family to Internet groups and Web sites might offer ideas for what might help you. 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 you feel better. Some methods that are used along with regular treatment are meditation 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 may lose the chance to be helped by standard medical treatment. Delays or interruptions in your 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 think about alternative methods. You want to do all you can to 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 have regular medical treatments? Is the treatment a "secret" that requires you to visit certain providers or travel to another country?
- Talk to your doctor or nurse about any method you are thinking about using.
- 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

Decisions about how to treat or manage your cancer are always yours to make. 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 your health care team, you may

be able to safely use the methods that can help you while avoiding those that could be harmful.

Treating specific types of brain and spinal cord tumors

The treatment options for brain and spinal cord tumors depend on several factors, including the type and location of the tumor and how far it has grown or spread.

Non-infiltrating astrocytomas

These tumors include juvenile pilocytic astrocytomas, which most commonly occur in the cerebellum in young people, and the subependymal giant cell astrocytomas, which are almost always associated with tuberous sclerosis. Many doctors consider these benign tumors.

In most cases, these astrocytomas are cured by surgery alone. But older patients are less likely to be cured. Radiation therapy may be given after surgery, particularly if the tumor is not completely removed, although many doctors will wait until there are signs the tumor has grown back before considering it. Even then, repeat surgery may be the first option.

The outlook is not as good if the astrocytoma occurs in a place that does not allow it to be removed surgically, such as the hypothalamus or brain stem. In these cases, radiation therapy is usually the best option.

For subependymal giant cell astrocytomas that can't be removed completely by surgery, treatment with a newer drug called everolimus (Afinitor) may shrink the tumor or slow its growth for some time.

Low-grade astrocytomas (Infiltrating or diffuse astrocytomas)

The initial treatment for these tumors is surgery when possible. These tumors are hard to cure by surgery because they often grow into (infiltrate) nearby normal brain tissue. Usually the surgeon will try to remove as much of the tumor as safely possible. If the surgeon is able to remove it all this may be curative.

Radiation therapy may be given after surgery, especially if large amounts of tumor remain. In younger adults, radiation may not be given unless the tumor shows signs of regrowth. (In some cases, a second surgery may be tried before giving radiation.) In those over age 40, radiation may be added after surgery because of the chance of recurrence. Chemotherapy may also be given after surgery in some cases. Some doctors may use genetic tests of the tumor to help determine if chemotherapy should be given

Radiation or chemotherapy may also be used as the main treatment if surgery is not a good option for some reason.

Intermediate- and high-grade astrocytomas (Anaplastic astrocytomas, glioblastomas)

Surgery is often the first treatment when it can be done, but these tumors are not curable by surgery. As much of the tumor is removed as is safely possible. Chemotherapy wafers may be placed in or near any remaining tumor at this time. Radiation therapy is then given, usually along with or followed by chemotherapy if the person's health allows. For tumors that cannot be treated with surgery, radiation therapy — with or without chemotherapy — is usually the best option.

Temozolomide is the chemotherapy drug most commonly used to treat these tumors. It is often given along with radiation therapy, as it appears to make it more effective. It is then continued after the radiation is completed. Temozolomide is the drug used first by most doctors because it crosses the blood-brain barrier, it's a pill, it's convenient to give, and it has been shown to help prolong life.

Cisplatin, carmustine (BCNU), and lomustine (CCNU) are other commonly used drugs. Combinations of drugs may also be used, such as the PCV regimen (procarbazine, CCNU, and vincristine). All of these treatments may shrink or slow tumor growth for some time, but they are not expected to be curative.

If standard chemotherapy drugs are no longer effective, the targeted drug bevacizumab (Avastin) may be helpful for some people, either alone or along with chemotherapy.

In general, these tumors are very hard to treat effectively for extended periods of time. Because these tumors are so hard to cure with current treatments, clinical trials of promising new treatments may be a good option.

Oligodendrogliomas and anaplastic oligodendrogliomas

If possible, surgery is the first option for oligodendrogliomas. Surgery usually doesn't cure them, but it can relieve symptoms and prolong survival. Many oligodendrogliomas grow slowly, especially in younger people, and may not need further treatment right away. Surgery may be repeated in many cases if the tumor grows back in the same spot. Radiation therapy and/or chemotherapy (most often with temozolomide or the PCV regimen) may also be options after surgery.

Oligodendrogliomas may respond to chemotherapy better than other brain tumors if certain chromosome changes are present in the tumor cells. You can ask your doctor about testing for these changes.

For tumors in which surgery is not an option radiation therapy or chemotherapy may be helpful.

Anaplastic oligodendrogliomas tend to be more aggressive. They are treated the same way as anaplastic astrocytomas (see above).

Ependymomas and anaplastic ependymomas

These tumors usually do not infiltrate normal brain tissue. They may be cured in some cases by surgery alone if the entire tumor can be removed, but often this is not possible. If only part of the tumor is removed with surgery (or if it is an anaplastic ependymoma), radiation therapy is given after surgery. If surgery cannot be done, radiation therapy is the main treatment.

Patients typically get an MRI of the brain and spine (and possibly a lumbar puncture) a few weeks after surgery if it is done. If either of these tests shows that the cancer may have spread through the cerebrospinal fluid, radiation therapy is given to the entire brain and spinal cord.

It is not clear how helpful chemotherapy is for these tumors — this is still being studied. Chemotherapy is usually not given unless the tumor can no longer be treated with surgery or radiation.

Meningiomas

Most meningiomas tend to grow slowly, so small tumors that aren't causing symptoms can often be watched rather than treated, particularly in the elderly.

If treatment is needed, these tumors can usually be cured if they are completely removed with surgery. Radiation therapy may be used along with, or instead of, surgery for tumors that can't be completely removed. If the tumor is an atypical (grade II) or anaplastic (grade III) meningioma (which tend to recur after treatment), radiation therapy is given after surgery even if all of the tumor has been removed.

For meningiomas that recur after initial treatment, further surgery (if possible) or radiation therapy may be used. If surgery and radiation aren't options, drug treatments (chemotherapy, immunotherapy, or hormone-like drugs) may be used, but it's not clear how much benefit they may offer.

Schwannomas (including acoustic neuromas)

These slow-growing tumors are usually benign and are cured by surgical removal. In some centers, small acoustic neuromas are treated by stereotactic radiosurgery (see the section "Radiation therapy"). For large schwannomas where complete removal is likely to cause problems, tumors may be operated on first to decrease their size and then the remainder is treated with radiosurgery. For the rare malignant schwannomas, radiation therapy is often given after surgery.

Spinal cord tumors

These tumors are treated in a manner similar to those in the brain. Astrocytomas of the spinal cord usually cannot be completely removed. They may be treated with surgery to remove as much tumor as possible, followed by radiation therapy, or with radiation therapy alone. Meningiomas of the spinal canal are often cured by surgical removal, as

are some ependymomas. If surgery doesn't completely remove an ependymoma, radiation therapy is often given.

Lymphomas

Treatment of central nervous system lymphomas generally consists of chemotherapy and/or radiation therapy. Treatment is discussed in more detail in our document, *Non-Hodgkin Lymphoma*.

Brain tumors that occur more often in children

Some brain tumors occur more commonly in children but do occur occasionally in adults. These include brain stem gliomas, germ cell tumors, craniopharyngiomas, choroid plexus tumors, medulloblastomas, primitive neuroectodermal tumors, and some others.

Treatment of these cancers is described in our document, *Brain and Spinal Cord Tumors in Children*.

Survival rates for selected brain and spinal cord tumors

Survival rates are a way for doctors and patients to get a general idea of the outlook (prognosis) for people with a certain type and stage of cancer. Some people want to know the statistics for people in their situation, while others may not find them helpful, or may even not want to know them. Whether or not you want to read about the survival statistics below is up to you.

The 5-year survival rate refers to the percentage of patients who live *at least* 5 years after being diagnosed. Of course, many of these people live much longer than 5 years. Five-year *relative* survival rates, such as the numbers below, assume that some people will die of other causes and compare the observed survival with that expected for people without the cancer. This is a more accurate way to describe the prognosis for patients with a particular type and stage of cancer.

In order to get 5-year survival rates, doctors have to look at people who were treated at least 5 years ago. Although the numbers below are among the most current available, improvements in treatment since then may result in a more favorable outlook for people now being diagnosed with brain and spinal cord tumors.

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. Knowing the type of tumor is important in estimating a person's outlook. But many other factors may also affect the outlook, such as the location of the tumor and whether it can be removed with surgery, as well as a person's age and overall health. Even when taking these other factors into account, survival rates are at best rough estimates. Your doctor can tell you if the numbers below may apply, as he or she is familiar with the aspects of your particular situation.

The numbers below come from the Central Brain Tumor Registry of the United States (CBTRUS) and are based on people who were treated between 1995 and 2007. As can be

seen below, survival rates for brain and spinal cord tumors vary widely by age, with younger people generally having better outlooks than older people. The survival rates for those 65 or older are generally lower than the rates for the ages listed below.

These numbers are for some of the more common types of malignant brain and spinal cord tumors. Numbers are not readily available for all types of tumors, often because they are rare or are hard to classify.

Type of Tumor	5-Year Relative Survival Rate		
	Age		
	20-44	45-54	55-64
Low-grade (diffuse) astrocytoma	59%	40%	NA*
Anaplastic astrocytoma	49%	29%	8%
Glioblastoma	16%	6%	3%
Oligodendroglioma	85%	77%	65%
Anaplastic oligodendroglioma	66%	53%	33%
Ependymoma/anaplastic ependymoma	91%	85%	84%

*NA = not available

More treatment information for brain and spinal cord tumors

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

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

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

What should you ask your doctor about brain and spinal cord tumors?

It is important for you to have honest, open discussions with your cancer care team. Feel free to ask any question, no matter how small it might seem. Here are some questions you

might want to ask. Be sure to add your own questions as you think of them. Nurses, social workers, and other members of the treatment team may also be able to answer many of your questions.

- What kind of tumor do I have? Is it benign or malignant?
- Where in the brain or spinal cord is the tumor and how far has it spread?
- Are there other tests that need to be done before we can decide on treatment?
- How much experience do you have treating this type of tumor?
- What treatment choices do I have? What do you recommend? Why?
- What is the goal of treatment (cure, prolonging life, relieving symptoms, etc.)?
- Will treatment relieve any of the symptoms I now have?
- What are the possible risks or side effects of treatment? What disabilities might I develop?
- What should I do to be ready for treatment?
- How long will treatment take? What will it involve? Where will it be given?
- What is my expected prognosis (outlook)?
- What would we do if the treatment doesn't work or if the cancer recurs?
- What type of follow-up will I need after treatment?

Along with these sample questions, be sure to write down any others you want to ask. For instance, you might want information about recovery times so that you can plan your work and activity schedule. Or you might want to ask about second opinions, as well as clinical trials for which you may qualify.

What happens after treatment for brain and spinal cord tumors?

For some people with brain or spinal cord tumors, treatment may remove or destroy the tumor. Completing treatment can be both stressful and exciting. You may be relieved to finish treatment, but find it hard not to worry about the tumor growing or coming back. (When a tumor comes back after treatment, it is called *recurrence*.) This is a very common concern in people who have had a brain or spinal cord tumor.

It may take a while before your fears lessen. But it may help to know that many cancer survivors have learned to live with this uncertainty and are leading full lives. Our document, *Living With Uncertainty: The Fear of Cancer Recurrence*, gives more detailed information on this.

For others, the tumor may never go away completely. Some people may continue to get treatment with radiation therapy, chemotherapy, or other treatments to try to help keep the tumor in check. Learning to live with a tumor that does not go away can be difficult and very stressful. It has its own type of uncertainty.

Follow-up care

If you have completed treatment, your doctors will still want to watch you closely. It is very important to keep all follow-up appointments. During these visits, your doctors will ask about symptoms, do physical exams, and may order lab tests or imaging tests such as MRI scans to watch for a recurrence of the cancer.

In some cases, even with slow growing tumors, some of the tumor may still be left behind after treatment. Even with tumors that are treated successfully, it is important to remember that some might come back, sometimes many years later.

Whether the tumor was completely removed or not, your cancer care team will want to follow up closely with you, especially in the first few months and years after treatment to make sure there is no progression or recurrence. Depending on the type and location of the tumor and the extent of the treatment, the team will decide which tests should be done and how often.

During this time, it is important to report any new symptoms to your doctor right away, so that the cause can be determined and treated, if needed. Your doctor can give you an idea of what to look for. If further treatment is needed at some point, the doctor will go over the potential options with you.

Should your tumor come back, the American Cancer Society document, *When Your Cancer Comes Back: Cancer Recurrence* can give you information on how to manage and cope with this phase of your treatment. You can get this document by calling 1-800-227-2345.

Recovering from the effects of the tumor and its treatment

The possible effects of the tumor and its treatment on physical and mental function can range from very mild to fairly severe.

Once you have recovered from treatment, doctors will try to determine the extent of any damage to the brain or other areas. Physical exams and imaging tests (CT or MRI scans) might be done after treatment to determine the extent and location of any changes that have occurred in the brain.

Several types of doctors and other health professionals may be involved in assessing any damage and helping you to recover.

A neurologist (a doctor who specializes in treating the nervous system) may assess your physical coordination and muscle strength. If there is muscle weakness or paralysis, you will be seen by physical and/or occupational therapists and perhaps a psychiatrist (a doctor

who specializes in rehabilitation) while in the hospital and/or as an outpatient for physical therapy.

If the speech center of the brain is damaged, a speech therapist will help you to improve communication skills.

If needed, an ophthalmologist (a doctor who specializes in eye problems) will check your vision and an audiologist may check your hearing.

After surgery, you may also see a psychiatrist or psychologist to determine the extent of any damage caused by the tumor or surgery.

If there is reason to think the pituitary gland at the base of the brain has been affected, you might also be seen by an endocrinologist (a specialist in hormone disorders). If hormone levels are affected, hormone treatments to restore normal levels may be needed for the rest of your life.

Keeping medical insurance and copies of your medical records

At some point after your diagnosis and treatment, you may see a new doctor who does not know about your medical history. It is important that you be able to give your new doctor the details of your diagnosis and treatment. Make sure you have this information handy:

- A copy of the pathology report(s) from any biopsies or surgeries
- Copies of imaging tests (CT or MRI scans, etc.), which can usually be stored on a CD, DVD, etc.
- If there was surgery, a copy of the operative report(s)
- If you stayed in the hospital, copies of the discharge summaries that doctors prepare when patients are sent home
- If you had chemotherapy, a list of the drugs, drug doses, and when they were given
- If you had radiation therapy, a summary of the type and dose of radiation and when and where it was given

It is also important to keep your health insurance. Tests and doctor visits cost a lot, and even though no one wants to think of a tumor coming back, this could happen.

Lifestyle changes

You can't change the fact that you have had cancer. What you can change is how you live the rest of your life – making choices to help you stay healthy and feel as well as you can. This can be a time to look at your life in new ways. Maybe you are thinking about how to improve your health over the long term. Some people even start during cancer treatment.

Making healthier choices

For many people, a diagnosis of cancer helps them focus on their health in ways they may not have thought much about in the past. Are there things you could do that might make you healthier? Maybe you could try to eat better or get more exercise. Maybe you could cut down on the alcohol, or give up tobacco. Even things like keeping your stress level under control may help. Now is a good time to think about making changes that can have positive effects for the rest of your life. You will feel better and you will also be healthier.

You can start by working on those things that worry you most. Get help with those that are harder for you. For instance, if you are thinking about quitting smoking and need help, call the American Cancer Society for information and support. This tobacco cessation and coaching service can help increase your chances of quitting for good.

Eating better

Eating right can be hard for anyone, but it can get even tougher during and after cancer treatment. Treatment may change your sense of taste. Nausea can be a problem. You may not feel like eating and lose weight when you don't want to. Or you may have gained weight that you can't seem to lose. All of these things can be very frustrating.

If treatment caused weight changes or eating or taste problems, do the best you can and keep in mind that these problems usually get better over time. You may find it helps to eat small portions every 2 to 3 hours until you feel better. You may also want to ask your cancer team about seeing a dietitian, an expert in nutrition who can give you ideas on how to deal with these treatment side effects.

One of the best things you can do after cancer treatment is put healthy eating habits into place. You may be surprised at the long-term benefits of some simple changes, like increasing the variety of healthy foods you eat. Getting to and staying at a healthy weight, eating a healthy diet, and limiting your alcohol intake may lower your risk for a number of types of cancer, as well as having many other health benefits.

Rest, fatigue, and exercise

Extreme tiredness, called *fatigue*, is very common in people treated for cancer. This is not a normal tiredness, but a "bone-weary" exhaustion that doesn't get better with rest. For some people, fatigue lasts a long time after treatment, and can make it hard for them to exercise and do other things they want to do. But exercise can help reduce fatigue. Studies have shown that patients who follow an exercise program tailored to their personal needs feel better physically and emotionally and can cope better, too.

If you were sick and not very active during treatment, it is normal for your fitness, endurance, and muscle strength to decline. Any plan for physical activity should fit your own situation. An older person who has never exercised will not be able to take on the same amount of exercise as a 20-year-old who plays tennis twice a week. If you haven't exercised in a few years, you will have to start slowly – maybe just by taking short walks.

Talk with your health care team before starting anything. Get their opinion about your exercise plans. Then, try to find an exercise buddy so you're not doing it alone. Having family or friends involved when starting a new exercise program can give you that extra boost of support to keep you going when the push just isn't there.

If you are very tired, you will need to balance activity with rest. It is OK to rest when you need to. Sometimes it's really hard for people to allow themselves to rest when they are used to working all day or taking care of a household, but this is not the time to push yourself too hard. Listen to your body and rest when you need to. (For more information on dealing with fatigue, please see *Fatigue in People With Cancer* and *Anemia in People With Cancer*.)

Keep in mind exercise can improve your physical and emotional health.

- It improves your cardiovascular (heart and circulation) fitness.
- Along with a good diet, it will help you get to and stay at a healthy weight.
- It makes your muscles stronger.
- It reduces fatigue and helps you have more energy.
- It can help lower anxiety and depression.
- It can make you feel happier.
- It helps you feel better about yourself.

And long term, we know that getting regular physical activity plays a role in helping to lower the risk of some cancers, as well as having other health benefits.

How about your emotional health?

During and after treatment, you may find yourself overcome with many different emotions. This happens to a lot of people.

You may find yourself thinking about death and dying. Or maybe you're more aware of the effect the tumor has on your family, friends, and career. You may take a new look at your relationships with those around you. Unexpected issues may also cause concern. For instance, you may see your health care team less often after treatment and have more time on your hands. These changes can make some people anxious.

Almost everyone who is going through or has been through tumor treatment can benefit from getting some type of support. You need people you can turn to for strength and comfort. Support can come in many forms: family, friends, cancer support groups, church or spiritual groups, online support communities, or one-on-one counselors. What's best for you depends on your situation and personality. Some people feel safe in peer-support groups or education groups. Others would rather talk in an informal setting, such as church. Others may feel more at ease talking one-on-one with a trusted friend or

counselor. Whatever your source of strength or comfort, make sure you have a place to go with your concerns.

The journey can feel very lonely. It is not necessary or good for you to try to deal with everything on your own. And your friends and family may feel shut out if you do not include them. Let them in, and let in anyone else who you feel may help. If you aren't sure who can help, call your American Cancer Society at 1-800-227-2345 and we can put you in touch with a group or resource that may work for you.

What happens if treatment is no longer working?

If a tumor keeps growing or comes back after one kind of treatment, it may be possible to try another treatment plan that might still cure it, or at least shrink the tumor enough to help you live longer and feel better. But when a person has tried many different treatments and the tumor has not gotten any better, it tends to become resistant to all treatment. If this happens, it's important to weigh the possible limited benefits of a new treatment against the possible downsides, including treatment side effects. Everyone has their own way of looking at this.

This is likely to be the hardest part of your battle with a tumor — when you have been through many medical treatments and nothing's working anymore. Your doctor may offer you new options, but at some point you may need to consider that treatment is not likely to improve your health or change your outcome or survival.

If you want to continue to get treatment for as long as you can, you need to think about the odds of treatment having any benefit and how this compares to the possible risks and side effects. In many cases, your doctor can estimate how likely it is the tumor will respond to treatment you are considering. For instance, the doctor may say that more treatment might have about a 1 in 100 chance of working. Some people are still tempted to try this. But it is important to think about and understand your reasons for choosing this plan.

No matter what you decide to do, it is important that you feel as good as you can. Make sure you are asking for and getting treatment for any symptoms you might have, such as nausea or pain. This type of treatment is called *palliative care*.

Palliative care helps relieve symptoms, but is not expected to cure the disease. It can be given along with tumor treatment, or can even be treatment. The difference is its purpose — the main purpose of palliative care is to improve the quality of your life, or help you feel as good as you can for as long as you can. Sometimes this means using drugs to help with symptoms like pain or nausea. Sometimes, though, the treatments used to control your symptoms are the same as those used to treat the tumor. But this is not the same as treatment to try to cure the tumor.

At some point, you may benefit from hospice care. This is special care that treats the person rather than the disease; it focuses on quality rather than length of life. Most of the time, it is given at home. Your tumor may be causing problems that need to be managed, and hospice focuses on your comfort. You should know that while getting hospice care

often means the end of treatments such as chemo and radiation, it doesn't mean you can't have treatment for the problems caused by your tumor or other health conditions. In hospice the focus of your care is on living life as fully as possible and feeling as well as you can at this difficult time. You can learn more about hospice in our document called *Hospice Care*.

Staying hopeful is important, too. Your hope for a cure may not be as bright, but there is still hope for good times with family and friends — times that are filled with happiness and meaning. Pausing at this time in your treatment gives you a chance to refocus on the most important things in your life. Now is the time to do some things you've always wanted to do and to stop doing the things you no longer want to do. Though the tumor may be beyond your control, there are still choices you can make.

What's new in brain and spinal cord tumor research and treatment?

There is always research going on in the area of brain and spinal cord tumors. Scientists are looking for causes and ways to prevent these tumors, and doctors are working to improve treatments.

Imaging and surgery techniques

Recent advances have made surgery for brain tumors much safer and more successful. One such technique is fluorescence-guided surgery. Using fluorescent dyes taken up only by the tumor that glow under special lighting from the operating microscope allows the surgeon to more successfully separate tumor from normal brain.

Radiation therapy

Several newer types of radiation therapy now allow doctors to deliver radiation more precisely to the tumor, which helps spare normal brain tissue from getting too much radiation. Techniques such as 3-dimensional conformal radiation therapy (3D-CRT), intensity modulated radiation therapy (IMRT), and proton beam therapy are described in the section "Radiation therapy."

Newer methods of treatment planning are also being studied. For example, image-guided radiation therapy (IGRT) uses a CT scan done just before each treatment to better guide the radiation to its target.

Chemotherapy

Newer approaches may help make chemotherapy more effective.

In addition to developing and testing new chemotherapy drugs, many researchers are testing new ways to get chemotherapy to the brain tumor.

Many chemotherapy drugs are limited in their effectiveness because the tightly controlled openings in the brain capillaries, sometimes referred to as the *blood-brain barrier*, prevents them from getting from the bloodstream to the brain. Researchers are now trying to modify some of these drugs by coating them with tiny layers of fat (liposomes) or attaching them to molecules that normally cross the blood-brain barrier, to help them work better. This is an area of active research and clinical trials.

For another newer method called *convection enhanced delivery*, a small tube is placed into the tumor in the brain through a small hole in the skull during surgery. The tubing extends through the scalp and is connected to an infusion pump, through which drugs can be given. This may be done for hours or days and may be repeated more than once, depending on the drug used. This is still an investigational method, and studies are continuing.

Other new treatment strategies

Researchers are also testing some newer approaches to treatment that may help doctors target tumors more precisely. In theory this should allow for more effective treatments that cause fewer side effects. Several of these treatments are still being studied.

Tumor vaccines

Several vaccines have been developed against brain tumor cells. Unlike vaccines against infectious diseases, these vaccines are meant to help treat the disease instead of prevent it. The goal of the vaccines is to stimulate the body's immune system to attack the brain tumor.

Early study results of a vaccine to help treat glioblastoma have shown promise, but more research is needed to determine how effective it is. At this time, brain tumor vaccines are available only through clinical trials.

Angiogenesis inhibitors

Tumors need to create new blood vessels (a process called *angiogenesis*) to keep their cells nourished. New drugs that attack these blood vessels are used to help treat some cancers. One of these drugs, bevacizumab (Avastin), has been approved by the FDA for use in recurrent glioblastomas based on its ability to shrink or slow the growth of some tumors. Further studies are trying to determine if it can help people live longer.

Other drugs that impair blood vessel growth, such as cilengitide, sunitinib (Sutent), and sorafenib (Nexavar), are being studied and are available through clinical trials.

Growth factor inhibitors

Tumor cells are often very sensitive to proteins called *growth factors*, which cause them to grow and divide. Newer drugs target some of these growth factors, which may slow the growth of tumor cells or even cause them to die. Several of these targeted drugs are

already used for other types of cancer, and some are being studied to see if they will work for brain tumors as well.

Hypoxic cell sensitizers

Some drugs increase the oxygen content in tumors, which may make tumor cells more likely to be killed by radiation therapy if they are given before treatment. Studies are underway to see if these types of drugs can improve the outcome of treatment.

Electric treatment fields

The NovoTTF-100A system has recently been approved by the FDA to treat glioblastomas that are no longer responding to other treatments. To use this device, the head is shaved and 4 sets of electrodes are placed on the scalp. The electrodes are attached to a battery pack and are worn for most of the day. They generate mild electric currents that are thought to affect tumor cells in the brain more than normal cells. In a clinical trial, people using the device lived about as long as those getting further chemotherapy, although they reported a better quality of life because of fewer side effects.

Additional resources for brain and spinal cord tumors

More information from your American Cancer Society

The following related information may also be helpful to you. These materials may be ordered from our toll-free number, 1-800-227-2345.

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

Caring for the Patient With Cancer at Home: A Guide for Patients and Families (also available in Spanish)

Clinical Trials: What You Need to Know

Imaging (Radiology) Tests

Living With Uncertainty: The Fear of Cancer Recurrence

Pain Control: A Guide for People With Cancer and Their Families (also available in Spanish)

Surgery (also available in Spanish)

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

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

When Cancer Comes Back: Cancer Recurrence

Books

The following books are available from the American Cancer Society. Call us at 1-800-227-2345 to ask about costs or to place your order.

American Cancer Society Complete Guide to Complementary & Alternative Cancer Therapies

American Cancer Society Complete Guide to Nutrition for Cancer Survivors

American Cancer Society's Guide to Pain Control, Second Edition

Cancer in the Family: Helping Children Cope with a Parent's Illness

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

What Helped Get Me Through: Cancer Patients Share Wisdom and Hope

What to Eat During Cancer Treatment

When the Focus Is on Care: Palliative Care and Cancer

National organizations and Web sites*

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

American Brain Tumor Association

Toll-free number: 1-800-886-2282

Web site: www.abta.org

National Brain Tumor Society

Toll-free number: 1-800-934-2873 (1-800-934-CURE)

Web site: www.braintumor.org

National Cancer Institute

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

Web site www.cancer.gov

National Coalition for Cancer Survivorship

Toll-free number: 1-877-622-7937 (1-877-NCCS-YES)

Web site www.canceradvocacy.org

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

The American Cancer Society is happy to address almost any cancer-related topic. If you have any more questions, please call us at 1-800-227-2345 at any time, 24 hours a day.

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