About Brain and Spinal Cord Tumors in Children

Overview and Types

If your child has just been diagnosed with brain or spinal cord tumors or you are worried about it, you likely have a lot of questions. Learning some basics is a good place to start.

- What Are Brain and Spinal Cord Tumors in Children?
- Types of Brain and Spinal Cord Tumors in Children

Research and Statistics

See the latest estimates for new cases of brain and spinal cord tumors in children in the US and what research is currently being done.

- What Are the Key Statistics About Brain and Spinal Cord Tumors in Children?
- What's New in Research and Treatment for Brain and Spinal Cord Tumors in Children?

What Are Brain and Spinal Cord Tumors in Children?

Brain and spinal cord tumors are masses of abnormal cells in the brain or spinal cord that have grown out of control. Cells in nearly any part of the body can become cancer, and can spread to other areas of the body. To learn more about how cancers start and spread, see What Is Cancer?

In most other parts of the body, it is very important to distinguish between benign (non-
cancerous) and malignant (cancerous) tumors. Benign tumors do not invade nearby tissues or spread to distant areas, so in other parts of the body they are almost never life threatening. One of the main reasons malignant tumors (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 and spinal cord tissue. Even so-called benign tumors can, as they grow, press on and destroy normal brain tissue, causing damage that is often disabling and can sometimes cause death. This is why doctors usually speak of “brain tumors” rather than “brain cancers.” The main concerns with brain and spinal cord tumors are how fast they grow, how readily they spread through the rest of the brain or spinal cord, and if they can be removed or treated and not come back. But both benign and malignant tumors can be life threatening.

Brain and spinal cord tumors in children tend to be different from those in adults. They often form in different places, develop from different cell types, and may have a different treatment and prognosis (outlook). For information about the differences between childhood cancers and adult cancers, see Cancer in Children.

The central nervous system

To understand brain and spinal cord tumors, it helps to know about the normal structure and function of the central nervous system (CNS), which 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 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 functions 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 liquid called cerebrospinal fluid (CSF). Cerebrospinal fluid is made by the choroid plexus, which is located in spaces in the brain called ventricles. The ventricles and 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 area 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 (voluntary) 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 where the tumor is. Common symptoms include:

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

**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 precise movements of hands, arms, feet, and legs; problems with swallowing or synchronized eye movements; and changes in speech rhythm.

**Brain stem:** The brain stem is the lower part of the brain that connects to the spinal cord. It has bundles of very long nerve fibers that carry signals controlling muscles and sensation or feeling between the cerebrum and the rest of the body. Special centers in the brain stem also help control breathing and the heart beating. In addition, most cranial nerves (described below) start in the brain stem.

The brain stem is divided into 3 main parts: the midbrain, pons, and medulla oblongata.

Tumors in this critical area of the brain can cause weakness, stiff muscles, or problems with sensation, facial or eye movement, hearing, 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 might not be possible to surgically remove tumors in this area.

**Spinal cord:** The spinal cord has bundles of very long nerve fibers that carry signals that control muscles, sensation or feeling, and bladder and bowel control.

Spinal cord tumors can cause weakness, paralysis, or numbness. The spinal cord is a narrow structure, so tumors that develop there usually cause symptoms on both sides of the body (for example, weakness or numbness of both legs). This is different from symptoms of most brain tumors, which often affect only one side of the body.

The nerves that reach the arms leave the spinal cord at the level of the neck (cervical spine). Nerves to the legs, bowel, and bladder branch off the spinal cord in the back (thoracic and lumbar spine). Spinal cord tumors in the neck (cervical spine) can cause symptoms in both the arms and legs, as well as affect bowel and bladder function. Spinal cord tumors below the neck only affect the legs and bowel and bladder function.
**Cranial nerves:** The cranial nerves extend directly out of the base of the brain (as opposed to coming out of the spinal cord). These nerves carry signals directly between the brain and the face, eyes, tongue, mouth, and some other areas.
The most common cranial nerve tumors in children are called *optic gliomas*, which are tumors of the optic nerve (the large nerve that runs between the brain and each eye). These tumors cause vision problems. Tumors starting in other cranial nerves can cause double vision; 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 develop into different types of tumors.

**Neurons (nerve cells):** These are the most important cells in the brain. They transmit chemical and electric signals that determine thought, memory, emotion, speech, muscle movement, sensation, 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 in the brain and spinal cord largely stop dividing about a year after birth (with a few exceptions). Neurons do not usually form tumors, but they can be damaged by tumors that start nearby.

**Gliial cells:** Gliial cells are the supporting cells of the brain. Most brain and spinal cord tumors develop from gliial cells. These tumors are sometimes referred to as a group called *gliomas*.

There are 3 types of gliial 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 cerebrospinal fluid (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 very early forms of nervous system cells that are probably involved in brain cell development. They are found throughout the brain. The most common tumors that come from these cells are called medulloblastomas, which start in the cerebellum.

Meninges: These are layers of tissue that line and protect the brain and spinal cord. The meninges help form the spaces through which CSF travels. 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. Tumors that start here include choroid plexus papillomas and choroid plexus carcinomas.

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 make hormones that help regulate the activity of several other glands in the body. 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 affect these functions. For example, tumors starting in the pituitary gland sometimes make too much of a certain hormone, which can cause problems. On the other hand, a child may have low levels of one or more hormones after treatment and may need to take hormones to make up for this.

Pineal gland: The pineal gland is not really part of the brain. It is a small endocrine gland that sits between the cerebral hemispheres. It makes melatonin, a hormone that regulates sleep, in response to changes in light. The most common tumors of the pineal gland are called pineoblastomas.

Blood-brain barrier: The inner lining of the small blood vessels (capillaries) in the brain and spinal cord creates a very selective barrier between the blood and the tissues of the central nervous system. This barrier 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.

- References
  See all references for Brain and Spinal Cord Tumors in Children
Types of Brain and Spinal Cord Tumors in Children

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

Brain tumors in children are more likely to start in the lower parts of the brain, such as the cerebellum and brain stem, than they are in adults. But they can start in the upper parts of the brain as well.

Gliomas

Gliomas are not a specific type of tumor. 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), anaplastic astrocytoma, astrocytoma, oligodendroglioma, ependymoma, brain stem glioma, and optic glioma. About half of all brain and spinal cord tumors in children are gliomas.

Astrocytomas

- Astrocytomas are tumors that start in cells called astrocytes, a kind of glial cell.
- 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 cerebrospinal fluid (CSF) pathways. It is very rare for them to spread outside of the brain or spinal cord.
- Astrocytomas are often grouped as high grade, intermediate grade, or low grade, based largely on how the cells look under the microscope.

Intermediate- and high-grade astrocytomas: These tumors tend to grow quickly and spread into the surrounding normal brain tissue. The highest-grade astrocytoma,
known as *glioblastoma*, is the fastest growing. Anaplastic astrocytomas are also in this group.

**Low-grade astrocytomas**: These tumors tend to grow slowly and are the most common type in children. Some special types, known as *non-infiltrating astrocytomas*, tend to grow very slowly and do not grow into (infiltrate) nearby tissues, so they often have a good prognosis.

- **Pilocytic astrocytomas** are slow growing and rarely infiltrate nearby tissues. They most commonly occur in the cerebellum but can also begin in the optic nerve, hypothalamus, brain stem, or other areas. They account for nearly 1 out of 5 brain tumors in children.
- **Subependymal giant cell astrocytomas** (SEGAs) occur in the ventricles. They are also slow growing and rarely infiltrate nearby tissues. These tumors are almost always linked with an inherited condition called *tuberous sclerosis*.
- **Fibrillary (diffuse) astrocytomas** are also slow-growing tumors, but with the important characteristic of growing into nearby tissues, which makes them hard to remove with surgery. Though these tumors are thought of as low grade, they tend to become more aggressive and fast growing over time.
- **Optic gliomas** are low-grade astrocytomas that start in the optic nerves (the nerves leading from the eyes to the brain). They are often linked with an inherited condition called *neurofibromatosis type 1*. These tumors are rarely fatal, but they may cause vision loss and injury to nearby brain tissue.

**Oligodendrogliomas**

These tumors start in brain glial cells called *oligodendrocytes*. These tumors tend to grow slowly, but like astrocytomas, most of them can grow into nearby brain tissue and can’t be removed completely by surgery. Oligodendrogliomas rarely spread along the CSF pathways and even less frequently spread outside the brain or spinal cord. Only about 1% of brain tumors in children are oligodendrogliomas. As with astrocytomas, they can become more aggressive over time.

**Ependymomas**

- About 5% of brain tumors in children are ependymomas. These tumors start in the ependymal cells that line the ventricles or central canal of the spinal cord. They can range from fairly low-grade (slow growing) 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. These tumors can block the flow of CSF out of the ventricles, causing the ventricles to become very large – a condition called *hydrocephalus*.

• Unlike astrocytomas and oligodendrogliomas, ependymomas usually do not grow into normal brain tissue. As a result, some (but not all) ependymomas can be removed and cured by surgery. But because they can spread along ependymal surfaces and CSF pathways, treating them can sometimes be difficult.

**Mixed gliomas**

These tumors contain more than one cell type. For example, oligoastrocytomas have some of the same types of cells as both oligodendrogliomas and astrocytomas. Treatment is typically based on the fastest-growing component of the tumor.

**Brain stem gliomas**

This term refers to the location of the tumor, rather than the type of cell it starts in. A small number of brain stem gliomas occur as a tumor with very distinct edges (called a *focal* brain stem glioma). More often, brain stem gliomas grow diffusely throughout the brain stem, rather than growing as a focal tumor. These tumors often start in the pons, where they are called *diffuse intrinsic pontine gliomas* (DIPGs).

About 10% to 20% of brain tumors in children are brain stem gliomas. Nearly all of these tumors are some type of astrocytoma.

**Primitive neuroectodermal tumors (PNETs)**

These tumors start in primitive (immature) cells of the central nervous system called *neuroectodermal cells*. About 1 out of 5 brain tumors in children are PNETs. They are more common in younger children than older ones, and are rare in adults. PNETs tend to grow quickly and often spread throughout the CSF pathways.

• **Medulloblastomas:** PNETs that start in the cerebellum are called *medulloblastomas*. Most PNETs in children are medulloblastomas. These tumors can often be treated effectively and tend to have a better outlook than PNETs in other parts of the brain.

• **Pineoblastomas:** PNETs that occur in the pineal gland are called *pineoblastomas*. These tumors are usually harder to treat than medulloblastomas.
Other PNETs: Other, less common types of central nervous system PNETs include medulloepitheliomas, ependymoblastomas, and neuroblastomas that start in the brain or spinal cord.

Craniopharyngiomas

These slow-growing tumors start above the pituitary gland but below the brain itself. They account for about 4% of brain tumors in children. These tumors may press on the pituitary gland and the hypothalamus, causing hormone problems. Because craniopharyngiomas start very close to the optic nerves, they can also cause vision problems. This makes them hard to remove completely without damaging the child's vision or hormone balance.

Mixed glial and neuronal tumors

Certain tumors that develop in children and young adults (and rarely in older adults) have both glial and neuronal cell components. They tend to have a fairly good prognosis.

- Pleomorphic xanthoastrocytoma (PXA) and dysembryoplastic neuroepithelial tumors (DNETs) look as if they could grow quickly when seen under the microscope, but these tumors tend to be fairly benign, and most are cured by surgery alone.
- Gangliogliomas is a type of tumor that has both mature neurons and glial cells. Most can be cured by surgery alone or surgery combined with radiation therapy.

Choroid plexus tumors

These rare tumors start in the choroid plexus within the ventricles of the brain. Most are benign (choroid plexus papillomas) and are cured by surgery. However, some are malignant (choroid plexus carcinomas).

Schwannomas (neurilemmomas)

This type of tumor starts in Schwann cells that surround and insulate cranial nerves and other nerves. Schwannomas are usually benign tumors. They often form near the cerebellum on the cranial nerve responsible for hearing and balance, in which case they
are called *vestibular schwannomas* or *acoustic neuromas*. They may also develop on spinal nerves past the point where the nerves have left the spinal cord. When this is the case, the tumor can press on the spinal cord, causing weakness, sensory loss, and bowel and bladder problems.

These tumors are rare in children. When schwannomas are found in a child, particularly if there are tumors on both sides of the head, it often means the child has an inherited tumor syndrome such as neurofibromatosis type 2 (see What are the risk factors for brain and spinal cord tumors in children?).

**Other tumors that start in or near the brain**

**Meningiomas**

These tumors begin in the meninges, the layers of tissue that surround the outer part of the brain and spinal cord. Meningiomas cause symptoms by pressing on the brain or spinal cord. They are much less common in children than in adults.

Meningiomas are almost always benign and are usually cured by surgery. Some, however, are located very close to vital structures in the brain and can’t be cured by surgery alone.

Meningiomas are often assigned a grade based on how the tumor cells look.

- Grade I tumors, which look most like normal cells, make up about 80% to 90% of meningiomas.
- Grade II (atypical) meningiomas look slightly more abnormal.
- Grade III (anaplastic) meningiomas, which look the most abnormal, make up only about 1% to 3% of meningiomas.

Higher-grade meningiomas are more likely to come back after treatment, and some grade III meningiomas can spread to other parts of the body.

**Chordomas**

These tumors start in the bone at the base of the skull or at the lower end of the spine. These tumors don’t start in the central nervous system, but they can injure nearby parts of the brain or spinal cord by pressing on them. Chordomas tend to come back after treatment, if they are not removed completely, causing more damage. They usually do not spread to other organs. Chordomas are much more common in adults than in
children. For more on these tumors, see *Bone Cancer*.

**Germ cell tumors**

These rare tumors develop from germ cells, which normally form eggs in women and sperm in men. During normal development before birth, germ cells travel to the ovaries or testicles and develop into eggs or sperm cells. But sometimes some germ cells don’t move where they should and end up in abnormal locations such as the brain. They may then develop into germ cell tumors, similar to those that can form in the ovaries or testicles.

Germ cell tumors of the nervous system usually occur in children, most often in the pineal gland or above the pituitary gland. These tumors can sometimes be diagnosed without a biopsy by measuring certain chemicals in the cerebrospinal fluid (CSF) or blood.

The most common germ cell tumor of the nervous system is the germinoma. Other tumors that start in germ cells include choriocarcinomas, embryonal carcinomas, teratomas, and yolk sac tumors (endodermal sinus tumors).

**Neuroblastomas**

These nerve cell tumors are the third most common cancer in children. Neuroblastomas rarely develop in the brain or spinal cord; most develop from nerve cells inside the abdomen or chest. This type of cancer is most common during early infancy. For more information, see *Neuroblastoma*.

**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 a small portion start in the central nervous system (CNS). CNS lymphomas are rare in children. For more on childhood lymphomas, see *Non-Hodgkin Lymphoma in Children*.

**Pituitary tumors**

Tumors that start in the pituitary gland are almost always benign (non-cancerous). But they can still cause problems if they grow large enough to press on nearby structures or if they make too much of any kind of hormone. These tumors are more common in teens than in younger children. For more information, see our document *Pituitary*.
Tumors.

Cancers that spread to the brain from other sites

Sometimes brain tumors are found not to have started in the brain but rather to have metastasized (spread) there from some other part of the body. Tumors that start in other organs and then spread to the brain are called metastatic or secondary brain tumors (as opposed to primary brain tumors, which start in the brain). This is important because metastatic and primary brain tumors are often treated differently.

In children, metastatic brain tumors are much less common than primary brain tumors. Childhood leukemias can sometimes spread to the CSF around the brain and spinal cord. When this happens, the cancer is still considered a leukemia (the cancer cells in the CSF are leukemia cells), so doctors use treatments directed at the leukemia. For more information, see Childhood Leukemia.

- References
See all references for Brain and Spinal Cord Tumors in Children

What Are the Key Statistics About Brain and Spinal Cord Tumors in Children?

Brain and spinal cord tumors are the second most common cancers in children (after leukemia). They account for about 1 out of 4 childhood cancers. More than 4,000 central nervous system tumors are diagnosed each year in children and teens. The incidence rate (number of tumors per 100,000 children) has not changed much in recent years.

Boys develop these tumors slightly more often than girls.

About 3 out of 4 children with brain tumors (all types combined) survive at least 5 years
after being diagnosed. The outlook can vary a great deal based on the type of tumor, where it is, and other factors. For survival information on some particular tumor types, see “Survival rates for selected brain and spinal cord tumors.”

Visit the American Cancer Society’s Cancer Statistics Center for more key statistics.

- References
See all references for Brain and Spinal Cord Tumors in Children

What’s New in Research and Treatment for Brain and Spinal Cord Tumors in Children?

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

Understanding gene changes in tumors

Researchers continue to look for the gene changes inside cells that result in brain and spinal cord tumors. The hope is that learning more about these gene changes may lead to better ways to treat these tumors.

For example, researchers have found that medulloblastomas can be divided into 4 main types, based on the different gene changes in the tumor cells. Some of these tumor types have a better outlook than others. Doctors are now learning how to use this information to help decide which children might need more or less intensive treatment.

More recently, researchers have identified some of the specific gene changes found in each type of medulloblastoma that might help the tumor cells grow. Some of these gene
changes can be targeted with new types of drugs, which are now being tested in clinical trials. In the future, doctors may be able to develop other drugs that specifically target these gene changes.

**Imaging and surgery techniques**

Recent advances have made surgery for brain tumors much safer and more successful. Some of these newer techniques include:

- **Functional magnetic resonance imaging** (fMRI, described in “How are brain and spinal cord tumors in children diagnosed?”), which can identify the site of important areas of the brain and how close they are to the tumor.

- **Magnetic resonance spectroscopic imaging** (MRSI, described in “How are brain and spinal cord tumors in children diagnosed?”). In this approach, specially processed MRS information is used to make a map of important chemicals involved in tumor metabolism. This is being developed to help surgeons direct their biopsies to the most abnormal areas in the tumor and to help doctors direct radiation and evaluate the effects of chemotherapy or targeted therapy.

- **Fluorescence-guided surgery**. For this approach, the patient drinks a special dye a few hours before surgery. The dye is taken up mainly by the tumor, which then glows when the surgeon looks at it under special lighting from the operating microscope. This lets the surgeon better separate tumor from normal brain tissue.

- **Newer surgical approaches** for some types of tumors. For example, a newer approach to treat some tumors in or near the pituitary (such as some craniopharyngiomas) is to use an endoscope, a thin tube with a tiny video camera lens at the tip. The endoscope is passed through a hole made in the back of the nose, which allows the surgeon to operate through the nasal passages and limits the potential damage to the brain. A similar technique can be used for some tumors in the ventricles, where a small opening in the skull near the hairline serves as the point of endoscope insertion. The use of this technique is limited by the tumor’s size, shape, position, and by how many blood vessels it contains.

**Radiation therapy**

Several newer types of radiation therapy now let doctors aim radiation more precisely at the tumor, which helps spare normal brain tissue from getting too much radiation. Newer techniques such as stereotactic radiosurgery, 3-dimensional conformal radiation therapy (3D-CRT), intensity modulated radiation therapy (IMRT), and proton beam
therapy are described in the section “Radiation therapy.”

The brain is very sensitive to radiation, which can lead to side effects if normal brain tissue receives a large dose, especially if the child is very young. Clinical trials have shown that in some situations, using chemotherapy can let doctors use lower doses of radiation therapy without lowering the chance that treatment will be effective. Doctors are now trying to determine if even lower doses of radiation can be used and still give the same results.

Chemotherapy

New approaches may help make chemotherapy (chemo) more useful against brain and spinal cord tumors.

Adjuvant chemotherapy

In some children and infants with brain tumors, chemo is given right after surgery to either delay radiation therapy (particularly in infants) or to decrease the radiation dose needed to treat the tumor. This is known as adjuvant chemotherapy. Some studies are looking at whether giving prolonged chemo can help avoid the need for radiation therapy at all in certain cases.

High-dose chemotherapy and stem cell transplant

One of the main factors that limits the doses of chemo that can be given safely is its effects on the bone marrow, where new blood cells are normally made. A stem cell transplant allows higher doses of chemo to be given than would normally be possible. First, blood stem cells are removed from either the child’s blood or the bone marrow and are stored in a deep freeze. The child is then treated with very high doses of chemo. The blood stem cells are then thawed and infused back into the body, where they settle in the bone marrow and start making new blood cells.

Although some children with certain brain or spinal cord tumors (such as medulloblastomas) have responded well to this very intensive treatment, it can have serious side effects, and it is not yet known if it is effective enough to become standard. For now, most doctors consider this treatment experimental for brain and spinal tumors. Clinical trials are being done to determine how useful it is.

Improving chemotherapy drugs
Many chemo 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 some parts of the brain tumor. 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.

Getting chemotherapy directly to tumors

Some newer approaches might help doctors get chemo directly to brain and spinal cord tumors.

For example, in one method called convection enhanced delivery, small tubes are 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 chemo drugs can be given. This can be done for hours or days and might be repeated more than once, depending on the drug used. This technique can also be used to get other, newer types of drugs into the tumor. 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. The hope is to develop more effective treatments that cause fewer side effects. Although these treatment approaches are promising, most are still experimental at this time and are only available through clinical trials.

Targeted drugs

As researchers have learned more about the gene changes in tumor cells that help them grow, they have developed newer drugs that target these changes. These targeted drugs work differently from standard chemo drugs.

One example of such a targeted drug is everolimus (Afinitor), which may shrink or slow the growth of subependymal giant cell astrocytomas (SEGAs) that can’t be removed with surgery (see "Targeted therapy for brain and spinal cord tumors in children").

Some types of medulloblastomas tend to have mutations (changes) in genes that are part of a cell signaling route called the hedgehog pathway. The hedgehog pathway is crucial for the development of the embryo and fetus, but it can be overactive in some
medulloblastoma cells. Drugs that target proteins in this pathway are now being tested against medulloblastoma in clinical trials.

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

**Angiogenesis inhibitors**

Tumors have 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, including some brain tumors in adults. Several drugs that impair blood vessel growth are now being studied for use against brain tumors in children.

**Hypoxic cell sensitizers**

Some drugs increase the oxygen content in the tumor, which makes tumor cells more likely to be killed by radiation therapy if the drugs are given before treatment. Studies are now looking to see if this affects treatment outcomes.

**Immunotherapy**

The goal of immunotherapy is to make the body’s own immune system fight the tumor.

Several types of vaccines are being 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 cells.

Early study results of some of these vaccines have shown promise, but more research is needed to determine how effective they are. At this time, brain tumor vaccines are available only through clinical trials.

Other types of drugs that affect the immune system, such as lenalidomide, are also being studied.

**Therapeutic viruses**

Researchers have done a great deal of lab work with viruses that reproduce only within brain tumor cells and then cause those cells to die, while leaving normal cells alone. Research using these viruses in humans with brain tumors is still in very early stages.