About Brain and Spinal Cord Tumors in Adults

Overview and Types

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

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

Research and Statistics

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

- Key Statistics for Brain and Spinal Cord Tumors
- What’s New in Adult Brain and Spinal Cord Tumor Research and Treatment?

What Are Adult Brain and Spinal Cord Tumors?

Brain and spinal cord tumors are masses of abnormal cells in the brain or spinal cord that have grown out of control.
In most other parts of the body, it is very important to distinguish between benign (non-cancerous) tumors and malignant tumors (cancers\(^1\)). Benign tumors do not grow into 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 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, press on and destroy 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 and spinal cord 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 tend to be different in adults and children. They often form in different areas, develop from different cell types, and may have a different outlook and treatment.

**Information on these types of tumors in children is covered in Brain and Spinal Cord Tumors in Children\(^2\).**

**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 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 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 special liquid, called cerebrospinal fluid (CSF). Cerebrospinal fluid is made by the choroid plexus, which is found in spaces within the brain called ventricles. The ventricles and the spaces around the brain and spinal cord are filled with CSF.
The main areas of the brain include the cerebrum, cerebellum, and brain stem. Each part has a special function.

**Cerebrum:** The cerebrum is the large, outer part of the brain. It has 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 swallowing or synchronizing 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 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 (see illustration below) start in the brain stem.

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.

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.

Tumors starting in cranial nerves can cause vision problems, trouble swallowing, hearing loss in one or both ears, or facial paralysis, numbness, or pain.

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 within it usually cause symptoms on both sides of the body (for example, weakness or numbness of both legs). This is different from most brain tumors, which often affect only one side of the body.

The nerves that reach the arms begin in the spinal cord at the level of 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). Most tumors of the spinal cord start in the neck and can cause symptoms in 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.

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 cells in the brain that help determine thought, memory, emotion, speech, muscle movement, sensation, and just about everything else that the brain and spinal cord do. They do this by transmitting chemical and electrical 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 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 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 very early forms of nervous system cells that are probably involved in brain cell development. They are found throughout the brain, although they are not often seen in the adult central nervous system. 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 \textbf{meningiomas}.

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

\textbf{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 \textbf{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, breast milk production and release, 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 person may have low levels of one or more hormones after treatment and may need to take hormones to make up for this.

\textbf{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 \textbf{pineoblastomas}.

\textbf{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 \textbf{chemotherapy}\textsuperscript{3} drugs that are used to kill cancer cells, which in some cases limits their usefulness.

\textbf{Hyperlinks}

1. \textit{www.cancer.org/cancer/cancer-basics/what-is-cancer.html}
3. \textit{www.cancer.org/treatment/treatments-and-side-effects/treatment-types/chemotherapy.html}

\textbf{References}
Types of Brain and Spinal Cord Tumors in Adults

Tumors that start in the brain (primary brain tumors) are not the same as 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 tumors are not treated the same way. For example, breast or lung cancers that spread to the brain are treated differently from tumors that start in the brain.

Unlike cancers that start in other parts of the body, tumors that start in the brain or spinal cord rarely spread to distant organs. Even so, brain or spinal cord tumors are rarely considered benign (non-cancerous). They can still cause damage by growing and spreading into nearby areas, where they can destroy normal brain tissue. And 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 have mixed cell types. Tumors in different areas of the central nervous system (CNS) may be treated differently and have a different prognosis (outlook).
Brain and spinal cord tumor grades

Some brain and spinal cord tumors are more likely to grow into nearby tissues (and to grow quickly) than are other tumors. The World Health Organization (WHO) divides brain and spinal cord tumors into 4 grades (using Roman numerals I to IV), based largely on how the cells look under the microscope:

- **Grade I**: These tumors typically grow slowly and do not grow into (invade or infiltrate) nearby tissues. They can often be cured with surgery.
- **Grade II**: These tumors also tend to grow slowly but they can grow into nearby brain tissue. They are more likely to come back after surgery than grade I tumors. They are also more likely to become faster-growing tumors over time.
- **Grade III**: These tumors look more abnormal under the microscope. They can grow into nearby brain tissue and are more likely to need other treatments in addition to surgery.
- **Grade IV**: These are the fastest growing tumors. They generally require the most aggressive treatment.

Gliomas

Gliomas are not a specific type of brain tumor. Glioma is a general term for tumors that start in glial cells. A number of tumors can be considered gliomas, including:

- **Astrocytomas** (which include glioblastomas)
- **Oligodendrogliomas**
- **Ependymomas**

About 3 out of 10 of all brain tumors are gliomas. Most fast-growing brain tumors are gliomas.

Astrocytomas

Astrocytomas are tumors that start in glial cells called astrocytes. 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 with 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 (like other brain tumors) are classified into 4 grades.

- **Non-infiltrating (grade I) astrocytomas** do not usually grow into nearby tissues and tend to have a good prognosis. These include pilocytic astrocytomas and subependymal giant cell astrocytomas (SEGAs). They are more common in children than in adults.

- **Low-grade (grade II) astrocytomas**, such as diffuse astrocytomas, tend to be slow growing, but they can grow into nearby areas and can become more aggressive and fast growing over time.

- **Anaplastic (grade III) astrocytomas** grow more quickly.

- **Glioblastomas (grade IV)** are the fastest growing. These tumors make up more than half of all gliomas and are the most common malignant brain tumors in adults.

**Oligodendrogliomas**

These tumors start in brain glial cells called oligodendrocytes. These are grade II tumors that tend to grow slowly. Most of these can grow into (infiltrate) nearby brain tissue and cannot be removed completely by surgery. Oligodendrogliomas sometimes spread along the CSF pathways but rarely spread outside the brain or spinal cord. As with astrocytomas, they can become more aggressive over time. Very aggressive (grade III) forms of these tumors are known as **anaplastic oligodendrogliomas**. Only about 2% of brain tumors are oligodendrogliomas.

**Ependymomas**

These tumors start in ependymal cells, which line the ventricles. They can range from fairly low-grade (grade II) tumors to higher grade (grade III) tumors, which are called **anaplastic ependymomas**. Only about 2% of brain tumors are ependymomas.

Ependymomas are more likely to spread along the cerebrospinal fluid (CSF) pathways than other gliomas 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 normal brain tissue. As a result, some (but not all) ependymomas can be removed completely 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 being cured with surgery, but treatment can cause side effects related to nerve damage.

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. Sometimes these tumors run in families, especially in those with neurofibromatosis², 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) meningiomas** have cells that look the most like normal cells. They account for about 8 of 10 meningiomas. Most of these can be cured by surgery³, but some grow very close to vital structures in the brain or cranial nerves and cannot be cured by surgery alone.

- **Grade II (atypical or invasive) meningiomas** usually have cells that look slightly more abnormal. They make up about 15% to 20% of meningiomas. They can grow directly into nearby brain tissue and bone and are more likely to come back (recur) after surgery.

- **Grade III (anaplastic or malignant) meningiomas** have cells that look the most abnormal. They make up only about 1% to 3% of meningiomas. They tend to grow quickly, can grow into nearby brain tissue and bone, and are the most likely to come back after treatment. Some may even spread to other parts of the body.

Medulloblastomas

Medulloblastomas develop from neuroectodermal cells (early forms of nerve cells) in the cerebellum. They are fast-growing (grade IV) tumors and often spread throughout the CSF pathways, but they can be treated by surgery⁴, radiation therapy⁵, and chemotherapy⁶.
Medulloblastomas occur much more often in children than in adults. They are part of a class of tumors called **embryonal tumors** that can also start in other parts of the central nervous system. They are discussed in more detail in [Brain and Spinal Cord Tumors in Children](#).

**Gangliogliomas**

Gangliogliomas contain both neurons and glial cells. These tumors are very uncommon in adults. They are typically slow growing (grade II) tumors and can usually be cured by surgery alone or surgery combined with radiation therapy.

**Schwannomas (neurilemmomas)**

Schwannomas develop from Schwann cells, which surround and insulate cranial nerves and other nerves. They make up about 8% of all CNS tumors.

Schwannomas are almost always benign (grade I) tumors. They can arise from any cranial nerve. When they form on the cranial nerve responsible for hearing and balance near the cerebellum they are called **vestibular schwannomas** or **acoustic neuromas**. They can also start on spinal nerves after the point where they have left the spinal cord. When this happens, they can press on the spinal cord, causing weakness, sensory loss, and bowel and bladder problems.

**Craniopharyngiomas**

These slow-growing (grade I) tumors start above the pituitary gland but below the brain itself. They may press on the pituitary gland and the hypothalamus, causing hormone problems. Because they start very close to the optic nerves, they can also cause vision problems. Their tendency to stick to these important structures can make them hard to remove completely without damaging vision or hormone balance. Craniopharyngiomas are more common in children, but they are sometimes seen in 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 brain or spinal cord by pressing on it.
These tumors are treated with surgery\textsuperscript{10} if possible, often followed by radiation therapy\textsuperscript{11}, but they tend to come back in the same area after treatment, causing more damage. They usually do not spread to other organs. For more information on chordomas, see Bone Cancer\textsuperscript{12}.

**Non-Hodgkin lymphomas**

Lymphomas are cancers that start in white blood cells called lymphocytes (one of the main cell types of the immune system). Most lymphomas start in other parts of the body, but some start in the CNS, and are called primary CNS lymphomas. These lymphomas are more common in people with immune system problems, such as those infected with HIV\textsuperscript{13}, the virus that causes AIDS. Because of new treatments for AIDS, primary 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 outlook for people with these cancers. For more information on primary CNS lymphomas (including treatment), see Non-Hodgkin Lymphoma\textsuperscript{14}.

**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. For more information, see Pituitary Tumors\textsuperscript{15}.

**Hyperlinks**

therapy.html

References


Last Medical Review: March 5, 2014 Last Revised: January 21, 2016

Key Statistics for Brain and Spinal Cord
Tumors

The American Cancer Society’s estimates for brain and spinal cord tumors in the United States for 2019 include both adults$^1$ and children$^2$.

- About 23,820 malignant tumors of the brain or spinal cord (13,410 in males and 10,410 in females) will be diagnosed. These numbers would be much higher if benign (non-cancer) tumors were also included.
- About 17,760 people (9,910 males and 7,850 females) will die from brain and spinal cord 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%. The risk for men (about 1 in 143) is slightly higher than that for women (about 1 in 185), although certain types of tumors are more common in women.

Survival rates for brain and spinal cord tumors vary widely, depending on the type of tumor (and other factors$^3$). Rates for some of the more common types of brain and spinal cord tumors are discussed in Survival Rates for Selected Adult Brain and Spinal Cord Tumors$^4$.

Visit the American Cancer Society’s Cancer Statistics Center$^5$ for more key statistics.

Hyperlinks

5. [https://cancerstatisticscenter.cancer.org/](https://cancerstatisticscenter.cancer.org/)

References

What’s New in Adult Brain and Spinal Cord Tumor Research and Treatment?

Research is always going on in the area of brain and spinal cord tumors. Scientists and doctors are looking for causes and ways to prevent these tumors, better tests to help characterize these tumors, and better ways to treat them.

Lab tests of brain tumors

In recent years, researchers have found some changes in genes, chromosomes, and proteins inside brain tumor cells that can be used to help predict a person’s outlook (prognosis) or help guide treatment. Some examples of changes that can now be tested for include:

- \( \text{IDH1 or IDH2 gene mutations} \)
- Chromosomal 1p19q co-deletions
- MGMT promoter methylation

For more on the use of these tests, see Tests for Brain and Spinal Cord Tumors in Adults\(^1\).

Researchers are looking for other changes in tumor cells that might help guide treatment.
Imaging and surgery techniques

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

- **Magnetic resonance spectroscopy (MRS) and magnetic resonance spectroscopic imaging (MRSI).** In this approach, described in Tests for Brain and Spinal Cord Tumors in Adults, specially processed MRS information is used to make a map of important chemicals involved in tumor metabolism. MRSI can help surgeons direct their biopsies to the most abnormal areas in the tumor. It can also help doctors direct radiation to the right areas and evaluate the effects of chemotherapy or targeted therapy.

- **Diffusion tensor imaging (DTI), also known as tractography.** This is a type of MRI test that can show the major pathways (tracts) of white matter in the brain. This information can be used by surgeons to help avoid these important parts of the brain when removing tumors.

- **Fluorescence-guided surgery.** For this approach, the patient drinks a special fluorescent dye a few hours before surgery. The dye is taken up by some tumors, which then glow when the surgeon looks at it under special lighting from the operating microscope. This lets the surgeon better separate tumor from normal brain tissue. Researchers are now looking to improve on the dyes currently in use.

- **Newer surgical approaches** for some types of tumors. For example, a newer approach to treat some tumors near the pituitary gland is to use a 3-D endoscope, a thin tube with a tiny video camera lens at the tip that allows the surgeon to see the small area around the tumor in 3 dimensions. The surgeon passes the endoscope through a small hole made in the back of the nose to operate through the nasal passages, limiting the potential damage to the brain. A similar technique can be used for some tumors in the ventricles, where an endoscope is inserted through a small opening in the skull near the hairline. The use of this technique is limited by the tumor’s size, shape, and position.

- **Laser interstitial thermal therapy (LITT).** For some tumors that are hard to treat surgically, another option might be to insert a thin probe with a tiny laser on the end through a small hole in the skull and into the tumor. The laser is then used to heat and destroy (ablate) the tumor. This technique is still fairly new, so doctors are still learning about the best ways to use it.

Radiation therapy
Some newer types of external radiation therapy let doctors deliver radiation more precisely to the tumor, which helps spare normal brain tissue. Techniques such as 3-dimensional conformal radiation therapy (3D-CRT), intensity modulated radiation therapy (IMRT), and proton beam therapy are described in Radiation Therapy for Adult Brain and Spinal Cord Tumors. 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

Along with 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 the drugs from getting from the bloodstream to the brain. Researchers are now trying to modify some of these drugs by putting them in tiny droplets 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.

Other new treatment strategies

Researchers are also testing some newer approaches to treatment that may help doctors target tumors more precisely. This could lead to treatments that work better and cause fewer side effects. Several of these treatments are still being studied.

Tumor vaccines

Several vaccines are being tested against brain tumor cells. Unlike vaccines against infections, 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 vaccines to help treat glioblastoma have shown promise, but more research is needed to determine how well they work. Researchers are also looking at combining vaccines with other treatments that could boost the immune response against tumor cells. 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, Mvasi)⁶, has been approved by the FDA to treat recurrent glioblastomas because it has been shown to slow the growth of some tumors.

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

Growth factor inhibitors

Tumor cells are often very sensitive to proteins called growth factors, which help them 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.

Hyperlinks


References


Last Medical Review: March 5, 2014 Last Revised: January 21, 2016

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