AMERICAN BRAIN TUMOR ASSOCIATION

Surgery



American Brain Tumor Association®

Providing and pursuing answers™

ACKNOWLEDGEMENTS

ABOUT THE AMERICAN BRAIN TUMOR ASSOCIATION

Association (ABTA) was the first national nonprofit organization dedicated solely to brain tumor research. The ABTA has since expanded our mission and now provides comprehensive resources to support the complex needs of brain tumor patients and caregivers, across all ages and tumor types, as well as the critical funding of research in the pursuit of breakthroughs in brain tumor diagnoses, treatments and care.

To learn more, visit **abta.org**.

We gratefully acknowledge Gene Barnett, MD, Department of Neurological Surgery and Chairman, The Cleveland Clinic Brain Tumor Institute, Susan Chang, MD, Professor in Residence and Vice Chair of Neurological Surgery and Lai Wan Kan Endowed Chair Director, Division of Neuro-Oncology Program Member, UCSF Comprehensive Cancer Center, The University of California, San Francisco, for their review of this edition of this publication.

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Surgery

WHAT IS SURGERY FOR A BRAIN TUMOR AND WHY IS IT DONE?

Whether you use the word "surgery," "resection," "operation," "brain operation" or "brain surgery," surgery is usually the first step in treating most benign and many malignant tumors. It is often the preferred treatment when a tumor can be removed without unnecessary risk of neurological damage.

Surgery might be recommended to:

- Remove or destroy as much tumor as possible
- Provide a tumor tissue sample for an accurate diagnosis and for genomic testing
- Remove at least part of the tumor to relieve pressure inside the skull (intracranial pressure), or to reduce the amount of tumor to be treated with radiation or chemotherapy
- Enable direct access for chemotherapy, radiation implants or genetic treatment of malignant tumors
- Relieve seizures (due to a brain tumor) that are difficult to control

"Radiosurgery" is a type of intense radiation delivered to a tumor. It may be used instead of, or in addition to, conventional surgery. Radiosurgery

Computer technology is an aid in tumor removal.
Gene Barnett, MD, The Cleveland Clinic Brain Tumor Institute, Cleveland, Ohio

is not surgery in the conventional sense, as no opening is made in the skull. In certain cases, it may offer similar benefit and lower risk or discomfort than conventional surgery.

Radiosurgery is discussed in our free publication ***Stereotactic Radiosurgery.*** *Please call us at 800-886-ABTA (2282) or visit www.abta.org if you would like a copy.*

WHEN MIGHT SURGERY NOT BE RECOMMENDED?

Before surgery your doctor will consider the following:

- **Location of the tumor.** Where the tumor is located will determine whether it is operable or inoperable.

WHAT IS AN "OPERABLE TUMOR?"

An operable tumor is typically one that your doctor believes can be surgically removed with minimal risk of brain damage.

WHAT IS AN "INOPERABLE TUMOR?"

In some cases surgery may not be possible because the tumor is so deep within the brain that it is not accessible without excessive risk of brain damage.

Tumors located in the brain stem and thalamus are two examples. Other tumors may present a problem if located near a sensitive area in the brain that controls language, movement, vision or other important functions.

New imaging technologies, mapping and planning systems, navigational tools, and imaging devices used during surgery can now provide neurosurgeons with a picture of the precise location and size of a tumor during a biopsy or surgery. These advances have greatly increased the accuracy of diagnosis and enable neurosurgeons to safely remove some tumors previously thought to be "inoperable" or "inaccessible."

- **Diagnosis and size of tumor.** If a tumor is benign, does not cause intracranial pressure (due to its small size) or cause problems with sensitive areas, avoiding or postponing surgery might be considered.
- **Number of tumors.** The presence of multiple tumors creates additional challenges to safe removal.
- **The borders, or edges, of the tumor.** If the tumor is poorly defined around the edges, it may be mixed with normal brain tissue and more difficult to remove completely.
- **Your general health.** Are your heart, lungs, liver and overall general health strong enough to endure the strains of surgery? If this is a metastatic brain tumor (one which began as a cancer elsewhere in your body), is the primary cancer controlled?
- **Your neurological status.** Do you have symptoms of increased intracranial pressure? Are there signs of nerve damage possibly caused by the tumor? If so, further evaluation may be needed before surgery is attempted.

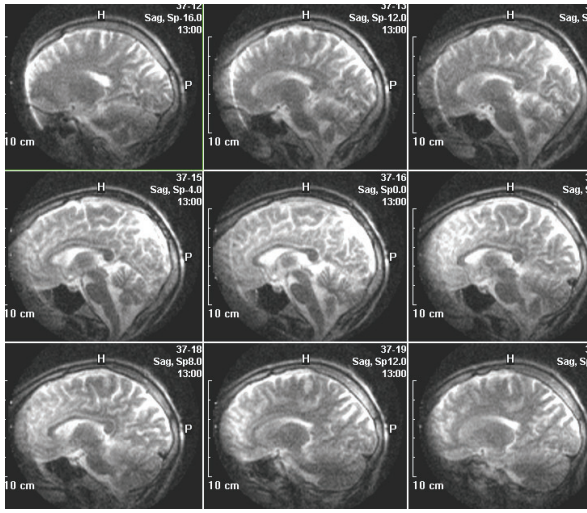
- **Previous surgery.** If you've had recent surgery, it is usually necessary to recover from the previous procedure before going through another one.
- **Other options.** Is it likely that another treatment would provide equal or better results at comparable or lower risk?

Your doctor will take these points into consideration in forming your treatment plan.

WHAT TESTS MIGHT BE USED TO HELP PREPARE FOR SURGERY?

Once surgery is confirmed, you will be given instructions for "pre-operative" lab work. Depending on the procedure to be done and your age, the doctor will order blood tests and a chest X-ray to verify your overall health. These will be done a few days before the procedure.

Additional images of your brain may be taken to help your doctor locate the tumor's precise location. These scans can also be used to help the



MRI scans

Medtronic Surgical Navigation Technologies, PoleStar iMRi images

team plan your surgical procedure. Highly sensitive scans are used for this purpose and may include:

- Computerized Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Magnetic Resonance Spectroscopy (MRS)
- Positron Emission Tomography (PET)

Your doctor might request functional imaging scans taken while you speak, read, write, or move your arms or legs. These are called functional MRIs, echo-planar MRIs, or ultrafast or BOLD MRIs. These scans help define vital areas of the brain that control language and movement centers.

Diffusion Tensor Imaging MRI's may be used to generate maps of the nerve pathways called "fiber tracking." Use of fiber tracking may help the surgeon avoid disrupting important nerve connections within the brain itself.

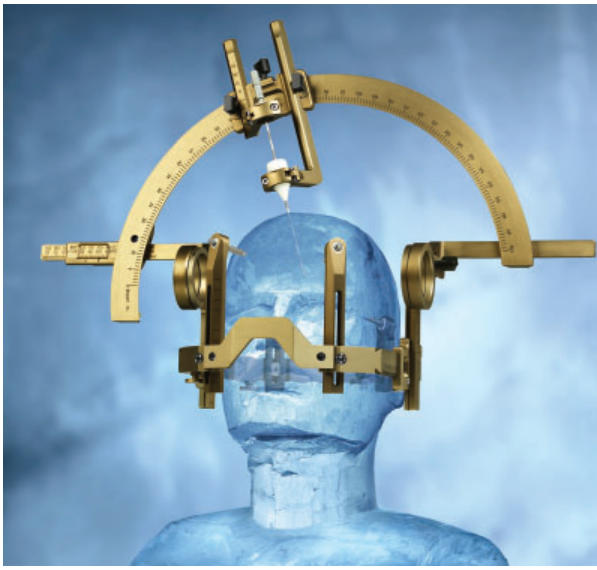
Vital areas can also be defined by a procedure called brain mapping. At the beginning of the surgery, tiny electrodes are placed on the outer layer of the brain. Stimulating these electrodes helps the neurosurgeon determine the functions of those sensitive parts of the brain so they can be avoided during surgery.

WHAT TYPE OF SURGERY MIGHT BE RECOMMENDED?

Before the procedure, the neurosurgeon will talk with you about the type of surgery planned. The words and the terms may be new to you, and therefore sound complicated. The most common types of surgery for brain tumors are listed below.

BIOPSY

A biopsy is a procedure to remove a sample of tumor tissue. A pathologist then microscopically examines the sample to determine the exact type of tumor. The tissue may also be analyzed for its chromosomal



Sample of a head frame used during stereotactic biopsy
Electra, LSS frame

makeup and other chemical (molecular) characteristics.

A biopsy may be performed for the sole purpose of obtaining a tissue sample. It may also be done as part of the surgery to remove the tumor.

There are three types of biopsy:

- **Needle biopsy.** After a small incision is made and a hole is drilled into the skull, a hollow needle is passed through the hole into the tumor. A small amount of tissue is drawn up into the hollow part of the needle for examination.
- **Stereotactic biopsy.** The same procedure as a needle biopsy but performed with a computer-assisted guidance system that aids in the location and diagnosis of the tumor.
- **Open biopsy.** The tissue sample is taken during an operation while the tumor is exposed.

CRANIOTOMY

A craniotomy is the most common type of surgery to remove a brain tumor. “Crani” means skull and

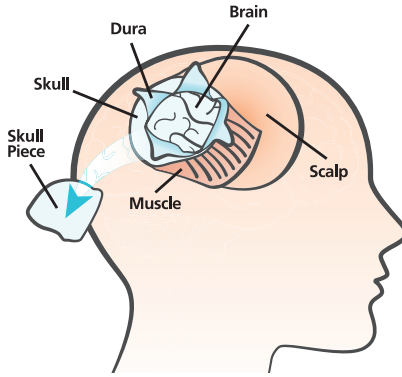


Illustration of Craniotomy

“otomy” means cutting into. The procedure typically involves shaving a portion of the head, making an incision in the scalp, then using specialized medical tools to remove a portion of the skull. This enables the neurosurgeon to find the tumor and remove as much as possible. After the tumor is removed, the portion of skull that was cut out is replaced, and the scalp is stitched closed. Remember, all of this is done with drugs that relax you or put you to sleep. They also numb the scalp and other tissues. The brain itself does not “feel” pain, so brain surgery can be done with you awake if the surgeon believes it is necessary to minimize the risk of the procedure.

CRANIECTOMY

A craniectomy is similar to a craniotomy in all ways except one. While “otomy” means cutting into, “ectomy” means removal. In a craniectomy the bone removed for access to the brain is *not* replaced before closing the incision. The neurosurgeon may perform a craniectomy if he or she expects swelling to occur following surgery, or if the skull bone is not reusable. When the bone is reusable it can be

replaced at a later date when it will not cause additional pressure. The skull piece is stored by the medical facility until a time when it might be reused. If a craniectomy is done, you will receive instructions from your health care team for protecting the soft spot created by the missing bone.

DEBULKING

The term "debulk" means to surgically reduce the size of a tumor by removing as much of it as possible. The term does not tell you how much of the tumor is removed or the type of procedure performed, although it implies the removal was less than complete. To say a tumor was "debulked," or that a patient underwent a "debulking" procedure, is medical language for saying a tumor was surgically removed.

PARTIAL REMOVAL

A "partial removal" means that the neurosurgeon chose to remove only part of the tumor due to risk of neurological damage. When partial removal is performed, the remaining tumor usually requires additional treatment such as radiation therapy or chemotherapy. Partially removed tumors also tend to regrow. The length of time it takes depends on the type of tumor and the amount of tumor remaining.

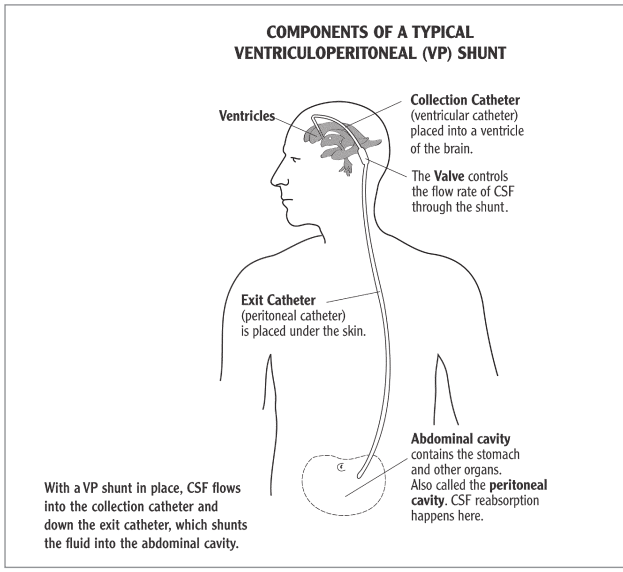
COMPLETE REMOVAL

A "complete removal" means that the neurosurgeon removed the entire tumor. Often the surgeon will call this a "gross total resection." MRIs taken after the surgery for "complete removal" typically show no presence of tumor. However, it is still possible that tumor cells might remain after a complete removal. These cells, which can grow back, are too small to be seen by the human eye or even by a surgical microscope. Following

the surgery, your neurosurgeon can tell you if regrowth is likely, based on your type of tumor. If so, additional therapy may be recommended to treat any remaining cells.

SHUNT

When there is excess fluid in the brain, or the fluid pathways are blocked due to a tumor or swelling, there may be a build-up of pressure inside the skull. A drainage system called a shunt can be used to remove the fluid. A shunt is a narrow, flexible tube used to move fluid from the brain to another part of the body. One end of the shunt is placed into one of four cavities, or ventricles, in the brain where cerebrospinal fluid (CSF) circulates. A small valve



Components of a typical ventriculoperitoneal (VP) shunt
McGill University Health Centre, Montreal, Canada

attached to tubing is placed under the scalp. The tubing is then threaded under the skin, down the neck, and into the abdominal cavity. Sometimes the shunt empties near the right atrium of the heart

rather than the abdomen. In either location, the fluid drains out of the shunt and is absorbed by the body. The shunt filter catches small pieces of tissue and stray tumor cells that might be in the CSF as it drains away from the brain. Small incisions in the neck, chest and/or abdominal area are made to attach the tubing securely. The shunt has a valve that permits the CSF to only flow away from the brain, and controls the rate of flow.

A shunt can be either temporary or permanent. Sometimes a tube is placed into one of the four cavities or ventricles in the brain and connected to a collecting bag outside of the body. This procedure is called a ventriculostomy and is a temporary way of draining the CSF.

After the shunt is in place, most patients, especially children, experience dramatic improvement within days or weeks. It is fairly common that a shunt might need maintenance. Reasons for this include blockage of the catheter, an infection, a disconnection, or in the case of a child, the catheter may need to be lengthened due to the child's growth. When these situations occur, a surgical procedure known as shunt revision may be done to correct the problem.

Shunts may not be used if the pressure in the brain is too high. Abruptly changing the pressure may cause the brain to shift upward or downward toward the spine. In this situation, the doctor will use other methods to reduce the pressure before a shunt is inserted.

OMMAYA RESERVOIR

An Ommaya reservoir is a small container surgically implanted under the scalp and attached to a tube. The tubing may lead into a ventricle of

the brain (where the CSF circulates) or into a fluid-filled cyst. This container can be used to:

- Deliver chemotherapy to the brain and the CSF surrounding the brain without having to undergo spinal taps
- Remove CSF from the reservoir to detect the presence of abnormal cells
- Remove cystic fluid when it accumulates without having to undergo surgery

Placement of a reservoir can be done in a 15–20 minute procedure. The Ommaya reservoir can be built into the catheter as part of a shunt, or as a stand-alone device. The reservoir can be removed if it is no longer needed.

SKULL BASE SURGERY

Skull base surgery refers both to the location of a tumor as well as a specialized technique used to remove a tumor in that area. The skull base is the delicate bony area that supports the bottom of the brain. Tumors located in this area often surround nerves and blood vessels involved in vision, smell, hearing, speech, swallowing, and eye and facial movements. Skull base surgery is challenging. It can involve removing the bone surrounding the brain and reassembling it again without disturbing the function of the crucial nerves or blood vessels in that area. This type of surgery can be very lengthy.

TRANSPHENOIDAL SURGERY

Transphenoidal surgery is an approach often used with pituitary adenomas and craniopharyngiomas. The term “trans” means through and “sphenoid” refers to the sphenoid bone located under the eyes and over the nose. The entry point for the neurosurgeon is through an incision made under the upper lip and over the teeth or directly through

the nostril. These are sometimes the most direct routes to the pituitary gland.

LASER INTERSTITIAL THERMAL THERAPY (LITT)

LITT uses a laser to heat brain tumor tissue while monitoring the destruction of the tissue with an MRI that can measure the temperature of the tissues in real time. The laser probe is directed into the tumor through one or more small holes using stereotactic techniques. The availability of LITT is relatively new and may provide the benefit of surgical removal for some tumors that are difficult or impossible to access with a conventional craniotomy.

WHAT TOOLS AND TECHNIQUES ARE AVAILABLE TO NEUROSURGEONS?

BRAIN MAPPING

While MRI and MRS scans give the neurosurgeon valuable information about the brain tumor, they don't precisely identify sensitive areas of the brain that are responsible for speech, comprehension, sensation or movement. Brain mapping during surgery helps the neurosurgeon detect critical areas and distinguish the margin of the tumor from the rest of the brain tissue. Brain mapping tools include:

- Direct cortical stimulation
- Somatosensory-evoked potentials
- Functional MRI
- Intraoperative ultrasound imaging
- Intraoperative MRI

Direct Cortical Stimulation

This technique identifies sensitive areas of the brain through direct contact with the brain tissue. A probe is used to stimulate certain areas of the

brain with a low dose of electrical current. As the probe touches an area of the brain, the electric current causes a visible movement of that related body part. If the patient is awake, this technique can also be used to locate critical areas in speech or sensation. This helps the neurosurgeon identify critical areas of the brain that must be carefully navigated.

Somatosensory-Evoked Potentials (SSEP)

In SSEP, low doses of electrical current are given to a limb or the face. Electrodes placed on the surface of the brain record the weak electrical impulses as they travel along nerves to the brain. These impulses are called "evoked potentials" and are another tool for identifying critical areas.

Functional MRI (fMRI)

This scanning technique takes faster images of the brain than traditional MRIs and creates pictures of the brain's use of oxygen. This helps distinguish between normal brain, which uses oxygen, and a tumor that contains dead cells and does not use oxygen. A functional MRI may also be referred to as *real-time MRI, fast MRI, echo-planar MRI* or *dynamic MRI.*

Intraoperative Ultrasound Imaging

During surgery, ultrasonic waves might be used to determine the depth of the tumor and its size. It works by sending ultrasonic pulses into the brain. These pulses are instantly reflected back. The time it takes for these "echoes" to bounce back is calculated by a computer and formed into an image on a screen. These images can help the neurosurgeon:

- Determine the shortest surgical route to the tumor
- Define the borders of the tumor
- Distinguish the tumor from a cyst, swelling (edema), and normal brain

An MRI scanner in the operative suite, called an iMRI, is seen on the right in the photo.
Linda Liau, MD, UCLA Medical Center, Los Angeles © Eric Behnke

Intraoperative MRI (iMRI)

Some operating rooms have specialized MRI machines that allow scans to be performed during surgery. These images provide the surgeon with similar information as intraoperative ultrasound, but usually produce more detailed pictures. They are particularly helpful in determining how much of the tumor has been removed, and they allow the surgeon to navigate using updated brain images. Although once available at only a few centers, iMRI is now more widely available.

EMBOLIZATION

If a tumor has a large number of blood vessels, surgery can be difficult due to the bleeding that could result. Embolization is a technique neurosurgeons use to stop the blood flow to the tumor prior to removing it. A diagnostic test, called an angiogram, is performed to determine if a significant amount of blood is going to the tumor. If so, the neurosurgeon or neuroradiologist can insert a small "plug" made of wire or glue-like material into the vessel.

Some microscopes allow surgeons to share the same view.
Carl Zeiss Surgical, Inc. NC33 Microscope

This stops the blood flowing to the tumor, but not to normal parts of the brain. Tumor removal usually follows within a few days. This technique might also be used with tumors that contain a high number of blood vessels – referred to as "vascular" or "well-vascularized" tumors. Meningiomas, meningeal hemangiopericytomas and glomus jugulare tumors are typically well-vascularized tumors.

CONVECTION-ENHANCED DELIVERY (CED)

One of the newest methods of delivering chemotherapy drugs or biologic therapies to a tumor is CED, or "convection enhanced delivery." CED uses the principles of constant pressure to "flow" or "infuse" substances through brain tumor tissue. The procedure begins with a surgery, during which a catheter (or multiple catheters, depending on the tumor size) is placed into the tumor area.

An operative microscope aids the neurosurgeon's view of the tumor.

John Sampson, MD, Duke University, Durham, North Carolina

The neurosurgeon then connects a pump-like device to the catheter, filling it with the therapeutic substance. The fluid then flows, by use of pressure and gravity, through the tumor area. This "bulk flow" or "convective-delivery" method bypasses the blood brain barrier, placing the therapeutic substance in direct contact with tumor tissue.

Clinical trials are exploring the use of CED as a way of placing immunotoxins, radioactive monoclonal antibodies and various chemotherapy drugs at the tumor site.

As this technique is developing, researchers are simultaneously exploring ways to include “tracers” in the substances flowing into the brain. Those tracers can be viewed on an MRI scan performed during CED, and may allow researchers to make real-time observations of the movement of therapeutic substances in and around the tumor. Research is also underway to predict the flow pattern that will occur after catheter placement.

LASERS

A laser is a surgical tool. It is a device that emits a narrow beam of intense heat that can cut and vaporize tissue during brain surgery.

The beams emitted by a laser do not pass through the dense bones of the skull. For a laser to be used effectively, it must first bypass the skull bones, using one of several surgical techniques.

Lasers may be especially important with tumors located at the base of the skull, deep within the brain or those tumors that cannot be removed easily for any number of reasons. Lasers are frequently used in microsurgery, photodynamic therapy and for a variety of diagnostic purposes. Laser probes may also be directed into deep tumors to heat them in the LITT process. Whether or not a neurosurgeon uses a laser during surgery depends on his or her personal judgment and the best “tools” for removal of any given tumor.

MICROSURGERY

Microsurgery involves the use of a high-powered microscope or other means of visual magnification

during surgery, along with tiny surgical tools that enable the neurosurgeon to perform exceptionally delicate operations. Microsurgery is used where the structures in the brain are very small and precise movement is crucial. This technique may be helpful in removing tumor wrapped around blood vessels or nerves, or along the bony ridges of the skull base.

NEURO-ENDOSCOPY

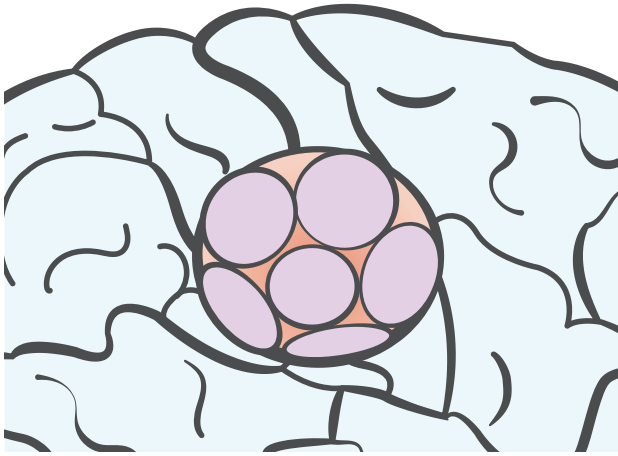
A neuro-endoscope, or endoscope, is a long, narrow tube that has a camera lens and a light source at the end. Endoscopes are used to visualize hollow pathways in the brain, such as the ventricles. The endoscope is inserted through a small hole in the skull, then threaded into a ventricle. The endoscope provides a lighted picture of the area as it appears at that moment, in "real-time." A surgical laser can also be attached, giving the neurosurgeon the ability to perform a biopsy within the ventricle, to remove blockage from a shunt, to remove tumors found in the ventricle and to remove cysts. Since this tool is long and very narrow, an endoscope is generally not used to remove larger tumors or tumors which are accessible with traditional surgical tools.

PHOTODYNAMIC THERAPY (PDT)

Photodynamic therapy is a procedure that involves the use of both a laser and a sensitizing drug. Just prior to surgery, the drug is injected into a vein or artery where it travels through the bloodstream and is absorbed by the tumor. The drug contains a special compound that causes tumor cells to appear a fluorescent "glowing green." During surgery, the neurosurgeon aims the laser at the tumor, which activates the drug and kills the tumor cells.

This type of therapy does have limitations:

- Only tumors that are considered operable can be treated with this method.



Wafer Placement in the Cavity Created by a Tumor Removal

- Only tumor cells that are visible to the neurosurgeon can be identified and treated using the sensitizing drug. Portions of a tumor may be hidden and not susceptible to light.
- Some tumors will not respond to the sensitizing drug.
- Tumors near the brain stem cannot be treated with this method due to the risk of swelling that might occur.

POLYMER WAFER IMPLANTS

Because the cells of a malignant tumor may spread into the area surrounding the tumor, additional therapies may be suggested. Polymer wafers, also called Gliadel wafers or wafer implants, are one of these forms of additional treatment. Soaked with chemotherapy drug, the wafers can be placed in the tumor site at the time of surgery.

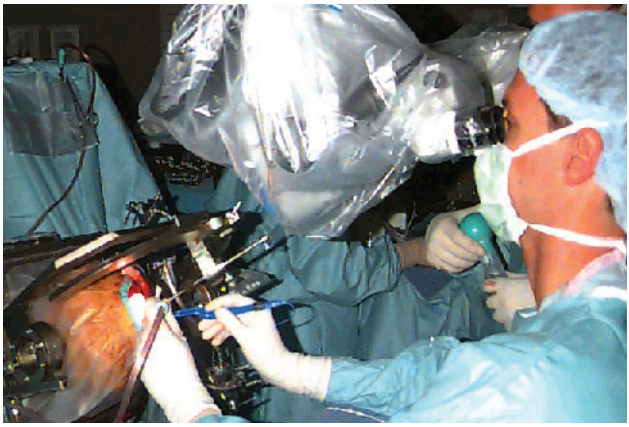
Traditional forms of chemotherapy are given by mouth or injected into your bloodstream through a vein. One of the more common drugs given in chemotherapy is called carmustine, or BCNU.

While BCNU has been shown to be effective in some patients, it can cause damage to the bone marrow when given into a vein. The bone marrow is where new blood cells are made. To avoid this side effect, researchers developed thin, dime-sized wafers soaked with BCNU that can be directly placed into the brain cavity where the tumor used to be. They can be inserted during the tumor removal surgery and require only a few additional minutes.

As the neurosurgeon removes the tumor, up to eight wafers can be implanted into the brain cavity. The neurosurgeon then surgically closes the area, allowing the wafers to do their work. These wafers gradually dissolve over a two to three week period and bathe the surrounding cells with BCNU. It is usually not necessary to remove the wafers since they are bio-degradable.

This method of delivering BCNU:

- Allows a controlled and predictable delivery of the chemotherapy drug to the tumor



The patient's head is in the stereotactic frame on the left side of the photo.

John Ruge, MD, Midwest Children's Brain Tumor Center at Advocate Lutheran General Hospital, Park Ridge, Illinois

- Eliminates the overall effects of traditional chemotherapy drugs on the body as they pass through the body on their way to the tumor
- Targets chemotherapy in the specific area that needs treatment
- May increase the risk of wound healing problems
- May make a patient ineligible for some clinical trials

STEREOTACTIC SURGERY

The use of highly advanced computers to locate and create a three-dimensional image of a tumor is called stereotaxy. When used during surgery, this technique is called stereotactic surgery. Conventional X-rays can only measure two dimensions: height and width. Stereotaxy adds the third dimension of depth, which enhances the neurosurgeon's ability to precisely map the location of the tumor and find the best and safest pathway for removing it.

Stereotactic techniques may be used to prepare for a surgery, during biopsy or tumor removal, while implanting radiation pellets, or to provide a navigation system during surgery. These techniques are especially useful in locating and removing tumors deep within the brain, such as brain stem and thalamic tumors. Stereotactic systems are used in operating rooms, enabling surgeons to view images of the brain as surgery is being performed. Some stereotactic techniques use a head frame and others do not.

Frame-Based Stereotactic Surgery

With frame-based stereotactic surgery, a lightweight frame is attached to the skull at four points. Local anesthesia is used to numb the places where the pins contact the skull. Once the frame is attached,

a CT, MRI or dye scan (angiography) is done. Since the scan images both the tumor and the frame, it is able to show the exact location of the tumor in three dimensions in relation to the head frame. The neurosurgeon takes these coordinates and precisely inserts a probe through a small incision in the skull to perform the biopsy or other procedure.

It also has some limitations: The frame can sometimes obstruct the neurosurgeon's view of the site; it can be time-consuming to manually set the frame and read the scans; there is a limited space to work within the radius of the arc; and the scans and surgery usually need to be performed the same day.

Frameless Stereotactic Surgery (Surgical Navigation, Neuronavigation)

Instead of using an external frame as a reference point, frameless stereotactic surgery uses tiny markers, called fiducial markers, that are taped or glued to the head before the brain is scanned. The scan is then loaded into a planning and navigation computer, producing a three-dimensional representation of the head, brain and tumor. During surgery these markers are touched with a pointing device, called a "wand."

Prototype of a surgical robot
Hunter Downs, PhD, NovaSol, Robotics Research 1607 test platform

Identified on the scan, the computer "knows" where the surgical instrument is during the procedure in relation to the brain and tumor.

There are many FDA-approved neuronavigation systems. Most are fully computerized guidance systems that give the neurosurgeon fast, continuous, “real-time,” three-dimensional information about the location of the tumor. Some use the patient’s own anatomy (eyes and nose) as reference points instead of the above-mentioned fiducial markers. These tools are particularly useful for complicated areas like skull base surgery and when multiple tumors must be removed.

Microscope-Based Devices

Also used during stereotactic surgical procedures are microscope-based devices. This technology tracks the exact position of the operating microscope with the fiducial markers placed on the head, giving precise coordinates for the tumor.

Previous CT or MRI scans are superimposed in the microscope so the neurosurgeon can see the tumor’s image as they work.

ROBOTIC SURGERY

The use of robotics to help surgeons perform delicate and prolonged surgeries is an important advancement in the field of microsurgery. Commonly called telerobotics or telepresence surgery, the system consists of a computer, microscope and mechanical arms that hold the appropriate instruments. The robotic arms move by hand-operated controls that look and feel like the instruments a surgeon uses for surgery. The computer reads the hand control movements and precisely moves the robotic arms in like manner to perform the procedure.

Telerobotic surgery is projected to be a great advance in neurosurgery once the technology has been refined. For now, telerobotic surgery is largely limited to research purposes.

In the future, the use of telerobotic surgery could:

- Reduce the demands on the surgeon during long and difficult procedures
- Increase technical performance with greater precision
- Allow surgeons to perform surgery from remote locations

ULTRASONIC ASPIRATION

This tool uses the vibration created by ultrasonic waves to break tumors apart and then suction out, or aspirate, the pieces. Suctioning minimizes the possibility of spreading tumor cells to other parts of the brain. This technique does not work as well on tumors that have a hard consistency.

DO I NEED A SECOND OPINION ABOUT SURGERY?

A second opinion is not always necessary. Many people obtain a second opinion and some get several opinions before proceeding with treatment. Common reasons for searching out a second opinion include:

- The peace of mind that comes with confirming the diagnosis and treatment plan with another doctor
- Exploring other treatment options
- Satisfying your insurance company's requirement for a second opinion (some insurers require a second opinion before paying surgical claims)

If you decide to seek another opinion there are several ways to do so:

- Ask your doctor to suggest someone with the expertise you need.
- Check with a hospital physician referral service that can direct you to members of their staff with a specialty in treating brain tumors.

- Confirm whether your insurance company requires you to stay within their network of providers. If so, they can provide you with names of physicians with experience in brain tumor treatment. If you choose to be treated out of network, be clear about what your costs will be.
- You can also visit ABTA's website, www.abta.org, for a listing of brain tumor treatment centers throughout the United States.

WHAT IS BOARD CERTIFICATION? HOW DO I KNOW IF MY NEUROSURGEON IS BOARD CERTIFIED?

Board certification is an advanced credential that indicates a high degree of competence and training in a certain medical specialty. A neurosurgeon seeking board certification within the American Board of Neurological Surgery (ABNS) must submit to a rigorous evaluation process governed by the American Board of Medical Specialties. Before board certification is granted, a neurosurgeon must:

- Validate appropriate education and training
- Demonstrate professional skills, judgment and knowledge – which includes opinions by his/her colleagues
- Pass both written and oral examinations in their specialty

Board certification is considered the "gold standard." It is a way for patients to assess the neurosurgeons they seek for treatment. You can ensure that your neurosurgeon is board certified by calling the American Board of Medical Specialties at 866-275-2267, by visiting their website (www.abms.org) or by calling the Physician Referral Service at the hospital where the doctor is on staff.

WHAT ARE THE POTENTIAL BENEFITS OF BRAIN TUMOR SURGERY?

The benefits of brain tumor surgery may:

- Establishes an accurate diagnosis. Every time tissue is taken from a tumor, whether through biopsy or removal, a pathologist will diagnose the tissue. Appropriate treatment planning requires an accurate diagnosis.
- Relieves pressure on the brain. This includes both general intracranial pressure and local pressure near the brain tumor.
- Can eliminate or improve many of the symptoms associated with the presence of a brain tumor. For instance, difficulty with thought processes might be improved or resolved after brain tumor surgery.
- Improves the effectiveness of additional therapies by reducing the number of cells to be treated.
- Tissue removed during surgery may be tested for genomic changes which may help guide treatment.
- Tissue may be used in clinical trials for vaccines.

Ask your doctor to help you balance the potential benefits and risks of surgery.

WHAT ARE THE COMMON RISKS OF BRAIN TUMOR SURGERY?

Brain tumor surgery poses both general and specific risks. The general risks apply to anyone going through surgery for any reason and are not limited to brain tumor surgery. These include:

- Infection
- Bleeding
- Blood clots
- Pneumonia
- Blood pressure instability

Risks specific to brain tumor surgery depend greatly on the particular location of the tumor. Particular areas of the brain control functions such as vision,

hearing, smell, movement of the arms and legs, coordination, memory, language skills, and other vital functions. The process of operating on the brain always includes some risk that nerves or blood vessels serving these areas will be damaged. This could result in partial or complete loss of sensation, vision, movement, hearing or other functions. When a tumor is located deep within the brain it increases the risk and range of possible complications.

Additional risks, while generally rare, are also possible. These brain surgery risks include:

- Seizures
- Weakness
- Balance/coordination difficulties
- Memory or cognitive problems
- Spinal fluid leakage
- Meningitis (infection causing inflammation of membranes covering the brain and spinal cord)
- Brain swelling
- Stroke
- Hydrocephalus (excessive fluid in the brain)
- Coma
- Death

WHAT IS INFORMED CONSENT?

Prior to surgery you may be provided with an informed consent document. Its purpose is to provide important details regarding the procedure and to obtain your voluntary consent to proceed. Most informed consent documents cover the following:

- Nature of the procedure
- Risks of the procedure
- Benefits of the procedure
- Alternatives available

Following surgery, you will be taken to a special care unit.
Peter Black, MD, Brigham and Women's Hospital, Boston, Massachusetts © BlueStar Media, LLP

- Consent to store extra tissue for research purposes (if the institution has a a tissue bank)

It is very important that you read the informed consent document carefully, and understand all that it says before you sign it. This might involve asking numerous questions about items that are not clear. It can also be very helpful to have a family member or friend present to read the document and ask additional questions. It is important to understand all the risks, benefits and alternatives after a discussion of these with your surgeons before agreeing to proceed with the procedure.

WHEN WILL MY PATHOLOGY REPORT BE BACK? HOW WILL I GET THOSE RESULTS?

At the time of your surgery, the neurosurgeon sends a piece of the tumor tissue to the hospital pathologist. The pathologist examines the tissue, determines the diagnosis, writes a report and sends the report to the neurosurgeon. It usually takes several days for this process to be completed.

In complex cases or when the tissue is sent to a pathologist at another hospital for diagnosis, it may take a week or more for your neurosurgeon to receive the final report. Additional tests for molecular changes in the chromosomes of the tumor cells may take even longer.

Once the neurosurgeon receives the report, you will typically be contacted to discuss the results.

HOW LONG WILL IT TAKE FOR ME TO RECOVER FROM SURGERY?

Any type of surgery is a trauma to your body. Because we each heal at our own pace, some people will recover faster than others. While there is no "normal" recovery period that applies to all people, your recovery time will depend on:

- The procedure used to remove your brain tumor
- The part of your brain where the tumor was located
- The areas of your brain affected by the surgery
- Your age and overall general health

Ask your neurosurgeon what you can expect as a reasonable recovery time. This will help you set realistic goals for yourself in the weeks following surgery.

WHEN YOUR SURGERY IS OVER

Once your pathology report comes back, your neurosurgeon will talk with you about the next part of your treatment plan. For some, surgery may be the only treatment needed, and your healing process now begins. For others, surgery is the first part of a multi-step treatment plan.

Make appointments for your follow-up doctor visits or scans and mark them on your calendar. Regardless of where you are in your treatment, your focus now is becoming well again.

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AMERICAN BRAIN TUMOR ASSOCIATION INFORMATION, RESOURCES AND SUPPORT

BROCHURES

Educational brochures are available on our website or can be requested in hard copy format for free by calling the ABTA. Most brochures are available in Spanish, with exceptions marked with an asterisk.

GENERAL INFORMATION

About Brain Tumors: A Primer for Patients and Caregivers
Brain Tumor Dictionary*
Brain Tumors Handbook for the Newly Diagnosed*
Caregiver Handbook*

TUMOR TYPES

Ependymoma
Glioblastoma and Anaplastic Astrocytoma
Medulloblastoma
Meningioma
Metastatic Brain Tumors
Oligodendroglioma and Oligoastrocytoma
Pituitary Tumors

TREATMENT

Chemotherapy
Clinical Trials
Conventional Radiation Therapy
Proton Therapy
Stereotactic Radiosurgery*
Steroids
Surgery

AMERICAN BRAIN TUMOR ASSOCIATION INFORMATION, RESOURCES AND SUPPORT

INFORMATION

ABTA WEBSITE | ABTA.ORG
Offers more than 200 pages of information, programs, support services and resources, including: brain tumor treatment center and support group locators, caregiver resources, research updates and tumor type and treatment information across all ages and tumor types.

EDUCATION & SUPPORT

- ABTA Educational Meetings & Webinars
  In-person and virtual educational meetings led by nationally-recognized medical professionals.

- ABTA Peer-to-Peer Mentor Program
  Connect with a trained patient or caregiver mentor to help navigate a brain tumor diagnosis.

- ABTA Connections Community
  An online support and discussion community of more than 25,000 members.

- ABTA CareLine
  For personalized information and resources, call 800-886-ABTA (2282) or email abtacares@abta.org to connect with a CareLine staff member.

GET INVOLVED

- Join an ABTA fundraising event.
- Donate by visiting abta.org/donate.

CONTACT THE ABTA

CareLine: 800-886-ABTA (2282)
Email: abtacares@abta.org
Website: abta.org

AMERICAN BRAIN TUMOR ASSOCIATION

8550 W. Bryn Mawr Avenue, Suite 550
Chicago, IL 60631

For more information contact:

CareLine: 800-886-ABTA (2282)
Email: abtacares@abta.org
Website: abta.org
Connect with us on social media:
Facebook.com/theABTA
Twitter.com/theABTA

To find out how you can get more involved locally, contact volunteer@abta.org or call 800-886-1281

American Brain Tumor Association®

Providing and pursuing answers™