MAYFIELD CLINIC & SPINE INSTITUTE

Epilepsy Surgery

advanced level

Overview

Epilepsy surgery is performed to treat seizures that are uncontrolled with medication. Approximately 70% of people with epilepsy have either complete or very good seizure control with medication (see Epilepsy). However, about 30% of people with epilepsy are not controlled with medication and are considered medically intractable. “Medically intractable seizures” are defined as persistent seizures despite trials of three or more appropriate antiepileptic drugs [1], alone or in combination. People with medically intractable seizures may be candidates for surgical treatment to achieve better seizure control.

What is epilepsy surgery?

Epilepsy surgery is a procedure to 1) remove the seizure-producing area of the brain or 2) limit the spread of seizure activity. It can be considered a curative procedure (stopping the seizures) or a palliative procedure (restricting the spread of the seizure). The type of epilepsy surgery you may have depends on the types of seizures you experience, and where they begin in your brain (Fig 1). Curative procedures such as lobectomy, cortical excision, or hemispherectomy are aimed at removing the area of the brain (seizure focus) causing seizures. The goal is to completely remove the seizure focus area without causing brain dysfunction. Palliative procedures, such as corpus callosotomy or vagus nerve stimulation (VNS), prevent the spread of the seizure by disconnecting brain pathways to stop or reduce seizure frequency (see Types of Epilepsy Surgery).

Who is a candidate?

Epilepsy surgery may be an option if you have:

- seizures that are uncontrolled with medications (intractable) or you have severe side effects to the medications
- partial seizures that always start in one area of the brain (localized seizure focus)
- seizures that significantly affect your quality of life
- seizures caused by a lesion such as scar tissue, a brain tumor, arteriovenous malformation (AVM), or birth defect
- seizure discharge that spreads to the whole brain (secondary generalization)

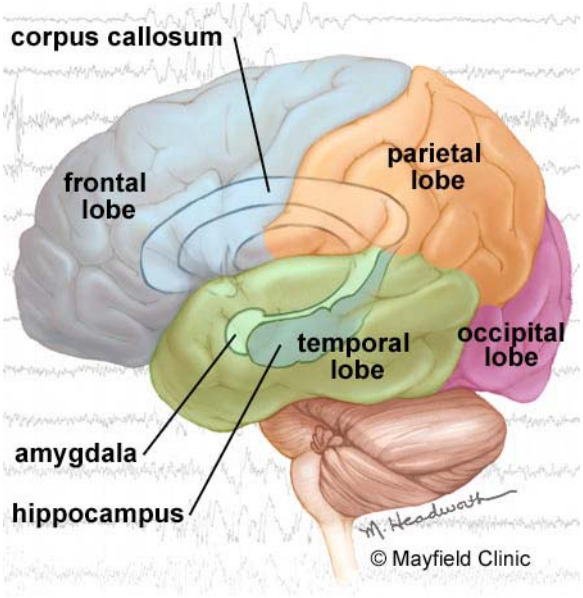

Figure 1. A seizure is an abnormal electrical discharge in the brain. This "short circuit" can cause a change in behavior (fall down, stare off into space, or make jerking movements) without your being aware of what is happening. Partial seizures arise from one part of the brain and include simple, partial, and complex partial seizures. Generalized seizures involve the entire brain and include generalized tonic-clonic, absence, myoclonic, tonic, and atonic seizures.

Types of epilepsy surgery

Curative procedures are performed when tests consistently point to a specific area of the brain where the seizures begin.

- **Temporal lobectomy** is the most common type of surgery for people with temporal lobe epilepsy. It removes a limited part of the anterior temporal lobe along with the amygdala and a portion of the hippocampus. A temporal lobectomy leads to a significant reduction or complete seizure control about 70% to 80% of the time [1]. Memory and language can be affected if this procedure is performed on the dominant hemisphere.
- **Cortical excision** is the second most common type of epilepsy surgery. It removes the outer layer (cortex) of the brain at the seizure focus area. About 40% to 50% of patients have better seizure control.

Most experts recommend that a patient who continues to have seizures after trials of 2 or 3 different medications should have an evaluation at a comprehensive epilepsy treatment program. The likelihood of seizure freedom after failure of 3 different medications is less than 5% [1]. The epilepsy team typically consists of epileptologists (neurologists with special expertise in epilepsy), neurosurgeons, neuropsychologists, epilepsy nurse clinicians, and EEG technicians.

Patients are initially evaluated by an epileptologist. A complete medical history and physical exam helps identify critical information, such as age of onset and type of seizures (including frequency, severity, and duration) (see Seizures). The physical exam is usually normal but may show some asymmetries of development compatible with early structural brain lesions, such as a difference in the size of one hand or foot compared to the other, which may correlate with atrophy of one hemisphere in the brain.

The following diagnostic studies may be included in an evaluation for epilepsy surgery. Not all tests are required. The epilepsy team will decide which tests are appropriate.

- **Continuous video-EEG monitoring** requires a hospital stay in an epilepsy monitoring unit. You will be monitored by a video camera and an electroencephalogram (EEG), which uses electrodes placed on your scalp to record the electrical activity of the brain. This monitoring allows observation of your behavior and EEG activity simultaneously during a seizure. Careful analysis of activity both during and between seizures can provide critical information about where the seizure starts and spreads. Certain behaviors during seizures, such as abnormal posturing of an arm, or specific speech problems during or following a seizure help pinpoint the brain area where the seizure starts.
- **Magnetic Resonance Imaging (MRI)** helps identify structural brain abnormalities that can cause epilepsy such as hippocampal atrophy, cavernous angiomas, cortical dysplasias, and tumors.
- **Positron Emission Tomography (PET)** allows the doctor to study your brain's function by observing how glucose (sugar) is metabolized in the brain. A small amount of radioactive glucose is injected into your bloodstream. The PET scanner takes pictures of the brain that are interpreted by a computer. A scan taken while a patient is having a seizure typically shows an increased use of glucose (hypermetabolism). A scan taken when a person is not having a seizure could show an area of decreased use of glucose (hypometabolism). These results may help locate areas of dysfunctional brain or other abnormalities, which could correspond to EEG localization of epileptogenic activity.

- **Hemispherectomy** involves the removal of the brain's outer layer (cortex) and anterior temporal lobe on one half of the brain. It is usually performed in children who already have a damaged hemisphere and intractable seizures with weakness on one side of the body. Seizures are controlled in about 80% of these patients with surgery. Many patients improve in cognitive functioning, attention span, and behavior.

Palliative procedures are performed when a specific brain area cannot be determined or when the seizure focus overlaps brain areas critical for movement, speech, or vision.

- **Corpus callosotomy** prevents the spread of generalized seizures from one side of the brain to the other by disconnecting the nerve fibers across the corpus callosum. A callosotomy is usually done in two stages. The first surgery sections the anterior two thirds of the corpus callosum. If the patient does not improve, a second surgery sections the posterior one third. This surgery does not cure the seizures; it prevents the spread and reduces seizure severity. Some patients experience disconnection syndrome after a complete callosotomy. The patient may have difficulty with right-left confusion with motor problems, apathy, and mutism.
- **Multiple subpial transections** involve making small incisions in the brain, which interfere with the spread of seizure impulses. This technique is used when the seizure focus is located in a vital area that cannot be removed. It may be used alone or in combination with a lobectomy.
- **Vagus nerve stimulation** (VNS) is used in people over age 12 who have partial or generalized seizures. VNS is not a cure for epilepsy, it does not work for everyone, and it does not replace the need for anti-epileptic drugs. This procedure is reserved for patients who are not candidates for potentially curative brain surgery. The VNS is similar to a pacemaker. A wire (lead) is wrapped around the vagus nerve in the neck and is connected to a generator-battery implanted under the skin near the collarbone. The generator is programmed to produce electrical signals that travel along the vagus nerve to the brain at regular intervals to help prevent seizures. The patient is also taught to use a magnet to turn the device on if he or she feels a warning (aura) that a seizure is about to start. VNS reduces seizure frequency by about 30% (similar to the results of the newer AEDs) [2]. Common side effects are a tingling sensation in the neck and mild hoarseness in the voice, both of which occur only during stimulation.

- **Single-Photon Emission Computed Tomography (SPECT)** provides information about blood flow to brain tissue. Analyzing blood flow to the brain may help determine how specific areas are functioning. Blood flow to an area of the brain during a seizure increases, while blood flow to an area of the brain can decrease when a person is not having a seizure.
- **Neuropsychological testing** evaluates your current level of brain functioning, including memory and language, which might correlate with diagnostic imaging and EEG.
- **Wada Test** (Intracarotid Amytal test) is used to determine which side of your brain is dominant for language and memory function. Surgeons need to know this information so that surgery does not affect these functions. A Wada test is done as part of an angiogram to detect any vascular or blood flow problems (see Angiogram). Sodium amytal is a short-acting barbiturate that is injected into one of the carotid arteries (right or left) and puts one half of the brain (hemisphere) to sleep. You will not be able to move one side of your body and may not be able to speak. You will be asked to identify pictures, words, objects, or numbers. After the drug wears off in 5 to 10 minutes you will have to answer questions and remember what was shown. The process is then repeated on the other side. This information is used in conjunction with the neuropsychological testing to help identify memory and language deficits and predict postoperative outcome.
- **Functional MRI (fMRI)** is used to determine the location of brain abnormalities in relation to areas of the brain responsible for speech, memory, and movement. FMRI also helps doctors predict the functional outcome of surgical treatment. FMRI is sometimes used instead of a Wada test.

Electrical brain mapping, or electrocorticography, may be necessary if the seizure focus cannot be located with standard EEG or other diagnostic tests. These diagnostic surgical tests use subdural or depth electrodes placed directly on or in the brain through a hole in the skull (craniotomy).

- **Subdural electrodes** look like a plastic grid and are placed directly on the brain surface (Fig 2). Subdural electrodes allow for a wide area of EEG recording as well as cortical mapping of functional areas.
- ***Intracerebral depth electrodes*** look like a banded stick and are placed stereotactically deep into the brain tissue, usually the amygdala and hippocampus of the temporal lobe. Depth electrodes are indicated for patients with bitemporal, bifrontal, or frontal temporal seizures.

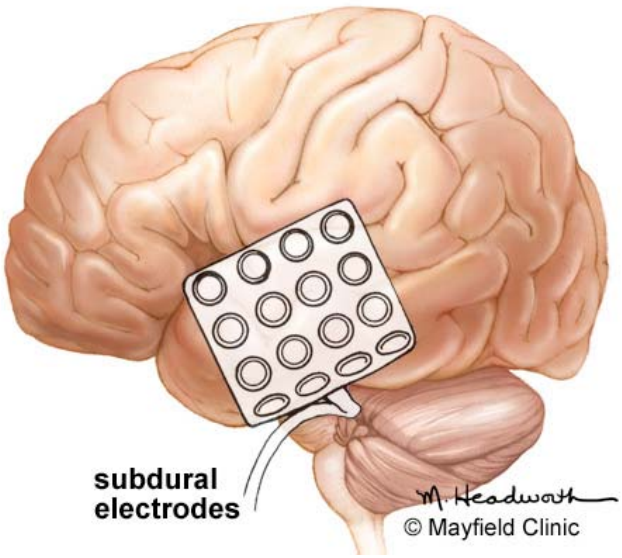

Figure 2. Subdural electrodes are placed directly on the brain surface to record electrical activity.

After electrode placement, the patient's head is bandaged and they are taken to the epilepsy monitoring unit. The electrodes are connected to an EEG machine to record precise information about your seizure. If the seizure focus can be located and is not in an area of the brain involved in communication, then that brain area may be removed in a second surgery. If no seizure focus is located then the electrodes are removed. Risks include infection and hemorrhage in about 2% to 5% of cases.

The surgical decision

The epilepsy team meets to review all testing performed to decide if surgery is the best treatment option. All tests should point to a single region in the brain as the source for seizures. If this is the case, and the region of seizure onset is a safe distance away from areas of the brain that control language, movement, and vision, then surgery can be recommend to reduce or eliminate seizures.

Who performs epilepsy surgery?

Epilepsy surgery is done by a neurosurgeon specifically trained in this field. The presurgical evaluation is done at a comprehensive epilepsy treatment program that includes a multidisciplinary team of specialists (neurologists, neurosurgeons, neuropsychologists, and nurse clinicians).

What happens before surgery?

You will have a consultation with a neurosurgeon. During the office visit, the surgeon will explain the procedure, its risks and benefits, and answer any questions. Next, you will sign consent forms and complete paperwork to inform the surgeon about

your medical history (i.e., allergies, medicines, vitamins, bleeding history, anesthesia reactions, previous surgeries). Discuss all medications (prescription, over-the-counter, and herbal supplements) you are taking with your health care provider. Some medications need to be continued or stopped the day of surgery. You may be scheduled for presurgical tests (e.g., blood test, electrocardiogram, chest X-ray) several days before surgery.

Stop taking all non-steroidal anti-inflammatory medicines (Naprosyn, Advil, Motrin, Nuprin, Aleve) and blood thinners (coumadin, Plavix, aspirin) 1 week before surgery. Additionally, stop smoking and chewing tobacco 1 week before and 2 weeks after surgery as these activities can cause bleeding problems. No food or drink is permitted past midnight the night before surgery.

Morning of surgery

- Shower using antibacterial soap. Dress in freshly washed, loose-fitting clothing.
- Wear flat-heeled shoes with closed backs.
- If you have instructions to take regular medication the morning of surgery, do so with small sips of water.
- Remove make-up, hairpins, contacts, body piercings, nail polish, etc.
- Leave all valuables and jewelry at home (including wedding bands).
- Bring a list of medications (prescriptions, over-the-counter, and herbal supplements) with dosages and the times of day usually taken.
- Bring a list of allergies to medication or foods.
- Take your AED medication as usual.

Arrive at the hospital 2 hours before your scheduled surgery time to complete the necessary paperwork and pre-procedure work-ups. You will meet with a nurse who will ask your name, date of birth, and what procedure you're having. They will explain the pre-operative process and discuss any questions you may have. An intravenous (IV) line will be placed in your arm. An anesthesiologist will talk with you and explain the effects of anesthesia and its risks.

What happens during surgery?

There are five main steps to an anterior temporal lobectomy. The surgery generally takes 3 to 4 hours.

Step 1: prepare the patient

You will lie on your back on the operative table and be given anesthesia. Once asleep, your head is placed in a skull fixation device attached to the table that holds your head in position during the surgery. Depending on where the incision needs to be made, your hair may be shaved.

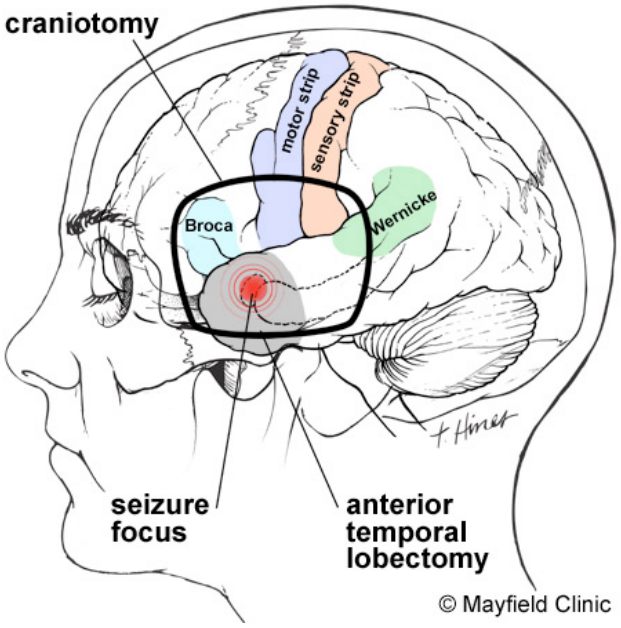

Figure 3. In an anterior temporal lobectomy, a bone flap (craniotomy) is cut in the skull to expose the brain. A part of the temporal lobe is removed along with the amygdala and a portion of the hippocampus (grey area).

Step 2: perform a craniotomy

After your scalp is prepped, the surgeon will make a skin incision to expose the skull. He will then make a circular opening in the skull, called a craniotomy, with a drill (see Craniotomy) (Fig 3). This bony opening exposes the protective covering of the brain, called the dura mater, which is opened with scissors.

Step 3: perform brain mapping

Intraoperative EEG recording and stimulation with subdural electrodes is performed to map brain areas (Fig 4). This is to reconfirm the epileptic zone, particularly the extent to which the lateral temporal cortex is involved. Using a small electrical probe, the surgeon tests locations on the brain's surface one after another to create a map of functions. In this kind of mapping, areas involved with movement can be identified electrically even if the patient is under anesthesia. To map functional areas such as language, sensation, or vision, however, the patient must actively participate. If this kind of mapping is needed, the patient is awakened from anesthesia to communicate with the surgeon.

Step 4: remove the seizure focus area

While looking through an operative microscope, the surgeon uses retractors to gently move the brain and open a corridor to the seizure focus area. The surgeon uses microsurgical instruments to remove that area of brain where active seizures occur.

Step 5: close the craniotomy
The retractors are removed and the dura is closed with sutures. The craniotomy bone flap is replaced and secured to the skull with titanium plates and screws. The muscles and skin are sutured back together.

What happens after surgery?

After surgery you'll be taken to the recovery room, where vital signs are monitored as you awake from anesthesia. Then you'll be transferred to the neuroscience intensive care unit (NSICU) for overnight observation and monitoring. Pain medication will be given as needed. You may experience nausea and headache after surgery; medication can control these symptoms. Once your condition is stable, you will be moved to a room on the Neuroscience floor where you will stay for about three days.

If you had a VNS implanted, you may go home after recovery from anesthesia. It is important to work with your neurologist to adjust your medications and refine the programming of the neurostimulator.

Discharge instructions

Discomfort

1. After surgery, headache pain is managed with narcotic medication. Because narcotic pain pills are addictive, they are used for a limited period (2 to 4 weeks). Their regular use may also cause constipation, so drink lots of water and eat high fiber foods. Laxatives (e.g., Dulcolax, Senokot, Milk of Magnesia) may be bought without a prescription. Thereafter, pain is managed with acetaminophen (e.g., Tylenol) and nonsteroidal anti-inflammatory drugs (NSAIDs) (e.g., aspirin; ibuprofen, Advil, Motrin, Nuprin; naproxen sodium, Aleve).
2. A medicine (anticonvulsant) may be prescribed temporarily to prevent seizures. Common anticonvulsants include Dilantin (phenytoin), Tegretol (carbamazepine), and Neurontin (gabapentin). Some patients develop side effects (e.g., drowsiness, balance problems, rashes) caused by these anticonvulsants; in these cases, blood samples are taken to monitor the drug levels and manage the side effects.

Restrictions

3. Do not drive after surgery until discussed with your surgeon and avoid sitting for long periods of time.
4. Do not lift anything heavier than 5 pounds (e.g., 2-liter bottle of soda), including children.
5. Housework and yardwork are not permitted until the first follow-up office visit. This includes gardening, mowing, vacuuming, ironing, and loading/unloading the dishwasher, washer, or dryer.

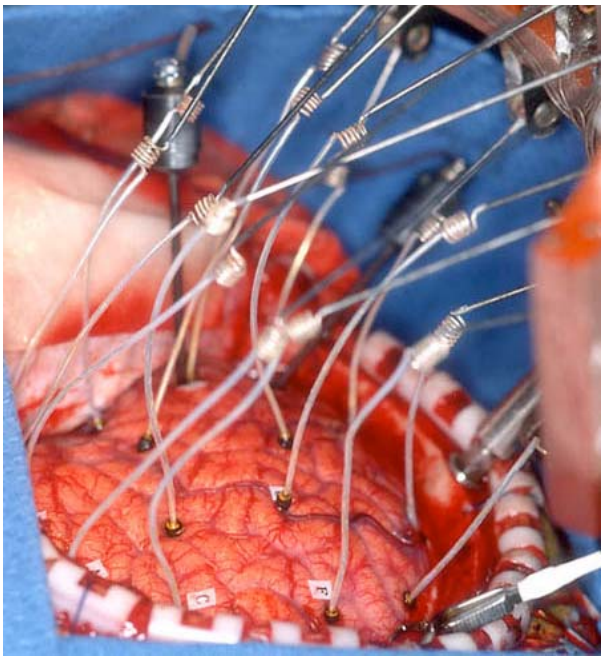

Figure 4. Brain mapping with electrodes placed directly on the brain confirms the area of seizure focus before brain tissue is removed.

6. Do not drink alcoholic beverages.

Activity

7. Gradually return to your normal activities. Fatigue is common.
8. An early exercise program to gently stretch the neck and back may be advised.
9. Walking is encouraged; start with short walks and gradually increase the distance. Wait to participate in other forms of exercise until discussed with your surgeon.

Bathing / Incision Care

10. You may shower and shampoo 3 to 4 days after surgery unless otherwise directed by your surgeon.
11. Sutures or staples, which remain in place when you go home, will need to be removed 7 to 14 days after surgery. Ask your surgeon or call the office to find out when.

When to Call Your Doctor

12. If you experience any of the following:

- A temperature that exceeds 101º F
- An incision that shows signs of infection, such as redness, swelling, pain, or drainage.
- If you are taking an anticonvulsant, and notice drowsiness, balance problems, or rashes.
- Decreased alertness, increased drowsiness, weakness of arms or legs, increased headaches, vomiting, or severe neck pain that prevents lowering your chin toward the chest.

Recovery

Patients usually can resume their normal activities after 3 to 4 weeks. However, you cannot drive an automobile until you have approval from your neurologist. Doctors usually recommend that surgical patients stay on AEDs for up to two years after the operation. Some people may have to continue with medication indefinitely for seizure control. If language or memory problems continue past the recovery period, your doctor may recommend speech or physical therapy.

What are the risks?

No surgery is without risks. General complications of any surgery include bleeding, infection, blood clots, and reactions to anesthesia. Specific complications related to a craniotomy may include:

- stroke
- seizures
- swelling of the brain, which may require a second craniotomy
- nerve damage, which may cause muscle paralysis or weakness
- CSF leak, which may require repair
- loss of mental functions
- permanent brain damage with associated disabilities

Specific complications may include:

- Memory and language problems after temporal lobectomy.
- Temporary double vision after temporal lobectomy.
- Increased number of seizures after corpus callosotomy, but the seizures should be less severe.
- Reduced visual field after a hemispherectomy.
- Partial, one-sided paralysis after a hemispherectomy. Intense rehabilitation often brings back nearly normal abilities.

Sources & links

If you have more questions, please contact the Mayfield Clinic at 800-325-7787 or 513-221-1100. For information about the University of Cincinnati Neuroscience Institute's Epilepsy Center, call 866-941-8264.

Sources

1. Wiebe S, Blume WT, Girvin JP, Eliasziw M: A randomized, controlled trial of surgery for temporal-lobe epilepsy. N Engl J Med 345:311–8, 2001
2. Schachter SC: Vagus nerve stimulation therapy summary. Neurology 59:S15-20, 2002.
3. Jooma R, Yeh HS, Privitera MD, Rigrish D, Gartner M: Seizure control and extent of mesial temporal resection. Acta Neurochir 133:44-9, 1995.

Links

Epilepsy Foundation of America, www.efa.org
American Epilepsy Society, www.aesnet.org
www.epilepsy.com
www.cincinnatiepilepsy.org

Glossary

antiepileptic drug (AED): a medication used to control epileptic seizures
cortical mapping: direct brain recording or stimulation to identify language, motor, and sensory areas of the cortex
cortex: the outer layer of the brain containing nerve cell bodies
disconnection syndrome: the interruption of information transferred from one brain region to another
generalized seizure: a seizure involving the entire brain
hippocampal atrophy: A wasting or decrease in size of the hippocampus
hypermetabolism: faster than normal metabolism
hypometabolism: slower than normal metabolism
ictal: that which happens during a seizure
interictal: that which happens between seizures
intractable: difficult to control
localization: finding the location in the brain where epileptic seizures start
lobectomy: surgical removal of a lobe of the brain
seizure focus: a specific area of the brain where seizures begin
palliative: to alleviate without curing
partial seizure: a seizure involving only a portion of the brain
video EEG monitoring: simultaneous monitoring of a patient's behavior with a video camera and the patient's brain activity by EEG

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