How epilepsy surgery is curing more seizures

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Lawrence Hirsch, MD, listens as Eyiyemisi Damisah, MD, reviews the plans for an upcoming epilepsy surgery. Credit: Anthony DeCarlo/Yale University

More than ever before, people with epilepsy are living normal lives. The key is to get treatment, typically a medication, for seizures—the unpredictable disruptions in the brain's electrical system that are the hallmark symptom of epilepsy. But treatment is more difficult for

people with refractory epilepsy—a subtype of the condition in which medication doesn't work well or at all. For years, their only option was to undergo an invasive operation, and many were told they weren't eligible for surgery and would have to live with the seizures.

But brain surgery techniques have been advancing, which has meant a revolution for those with refractory epilepsy.

"Care has changed so much, even in the last several years, that many people who were once told they weren't candidates for epilepsy surgery are now eligible," says Lawrence Hirsch, MD, a Yale Medicine neurologist, epilepsy specialist (or epileptologist), chief of the Yale School of Medicine Division of Epilepsy and EEG (a test that measures electrical activity in the brain), and co-director of the Yale Comprehensive Epilepsy Center.

The advances are myriad. Some changes are new; others are existing treatments that have undergone various refinements. They include brain-mapping techniques that help surgeons preserve areas responsible for critical functions, such as memory and language, and minimally invasive approaches that allow the brain to be accessed through tiny holes in the skull using a robot for precision. Usually, the latter is done to remove the abnormal tissue in the brain responsible for the condition, but if that's not an option, a device may be implanted to help control seizures.

Treatment, in general, is more comfortable, less invasive, and safer.

Dr. Hirsch and other Yale Medicine epilepsy specialists answered questions about the latest approaches and advances in refractory epilepsy treatment and how they are giving more patients a better quality of life—and, in some cases, providing a cure.

What is epilepsy?

Epilepsy is the broad term for a brain disorder that causes seizures. The diagnosis is given to people after they've had two or more seizures that last a few seconds or minutes and that are not a symptom of another acute or reversible medical condition. In some cases, epilepsy is a symptom of pre-existing conditions such as stroke, brain tumors, or moderate to severe traumatic head injury, though often there is no apparent cause.

About 3 million adults and 470,000 children have "active epilepsy," according to the Centers for Disease Control and Prevention (CDC). The agency bases its latest statistics on national data sources, including the 2015 National Health Interview Survey (NIHS), a continuing survey that collects data on a broad range of topics. The CDC defined active epilepsy in adults in the NHIS as having a history of doctor-diagnosed epilepsy or a seizure disorder and currently taking medication to control it or having had one or more seizures in the past year (or both).

What are seizures?

There are two main types of seizures: focal (or partial) seizures, which affect one area of the brain, and generalized seizures, which affect both sides of the brain.

Seizures affect people differently, and one person can have different types of seizures. They can be as simple as a brief period of limb twitching while fully alert or suddenly feeling dazed—so quick as to be barely noticed. Or they can be more severe, including losing consciousness, falling to the ground, and having whole-body stiffening and/or muscle jerks or spasms. The most severe type of seizure is known as a "bilateral tonic-clonic" seizure, commonly referred to as a "convulsion" or "grand mal" seizure.

Is medication for epilepsy effective?

Medication is still the first line of treatment for epilepsy. There are more than two dozen drugs that can lower the level of electrical activity in the brain, helping to prevent or reduce the number of seizures. "This usually affords patients the choice of a medication with no side effects," says Dr. Hirsch. "Years ago, many accepted side effects as a trade-off for seizure control, but that is no longer necessary for the majority of patients."

While drugs won't cure epilepsy, they allow an estimated 70% of people with the condition to manage it to the point where it barely interferes with their daily life, explains Dr. Hirsch. Some people may be able to stop taking their epilepsy medication if they have had no seizures for several years, but others will need medication all their lives.

"Unfortunately, the 30% of people who don't benefit from drugs often struggle with their epilepsy," says neurosurgeon Eyiyemisi Damisah, MD, an epileptologist and chief of Epilepsy Surgery for Yale Medicine. "We often see patients who have tried multiple medicines, but they were either ineffective or had intolerable side effects. So, they've continued to have seizures."

When should I consider surgery for epilepsy?

Epilepsy surgery might be considered if two or more anti-seizure medications (without significant side effects) are tried and don't stop the seizures, giving the condition the classification of refractory epilepsy. The goal of surgery is to identify and target the area (or areas) in the brain causing the seizures and remove or otherwise disable it, without harming nearby areas that regulate important functions, such as speech or memory.

Sometimes, surgery is a straightforward process—for instance, when an abnormal lesion in the brain is easily identified and located in an area where it is safe to remove. But there are cases where a visible lesion can't be identified, and a procedure to implant a device that can manage seizures may be the better option (more on that below).

How is the origin of the seizures identified prior to surgery?

Any epilepsy surgery includes careful planning. For the patient, this can mean multiple tests to better understand the cause of their epilepsy. "It's a very extensive and extremely well-thought-out process," says neurologist and epileptologist Adithya Sivaraju, MD, MHA. For some patients, the span of time to complete these tests can be as long as a few months, including a hospital admission.

For surgical evaluations, it is important to record seizures in the Epilepsy Monitoring Unit, a special unit in the hospital where the patient undergoes continuous video and EEG monitoring (more on that below). Medication is often lowered while in this unit to help capture a seizure.

The surgical planning process also includes (but is not limited to) MRI and/or PET scans, as well as tests that create different pictures of the brain to show abnormalities that could be responsible for seizures.

The most common test for epilepsy is an electroencephalogram (EEG), which involves pasting electrodes to the patient's scalp to evaluate the electrical activity in the brain. If a patient is having a seizure, an EEG recording often shows the activity as rapid spiking that can help clarify the type of epilepsy a person has and from which region of the brain the seizures arise. For instance, generalized spikes can represent generalized seizures (coming from all parts of the brain).

If other tests are inconclusive, an intracranial (inside the skull) EEG can provide more information. This involves an invasive procedure performed under general anesthesia; however, the procedure is usually less invasive than it was 10 years ago, when it involved temporarily removing a section of the skull.

In many cases, the intracranial EEG requires only very small electrodes to be inserted into the brain through tiny holes in the scalp; this is also referred to as "stereo-EEG." Computers, robots, and extensive imaging of the brain and blood vessels allow this to be done very safely and comfortably, explains Dr. Sivaraju.

Once the procedure is complete, the patient moves to the Epilepsy Monitoring Unit with equipment to record their brain activity 24/7 for a few days or up to two weeks. "This can help us determine, within almost a centimeter of precision, the part of the brain we need to target," Dr. Sivaraju says.

The intracranial EEG is also a tool used for brain mapping, a process to determine the locations that regulate key functions to make sure they don't overlap with an area that will undergo surgery. "If we are going to resect [or remove] a certain part of the brain, we must ensure that we're not causing any functional deficit to the patient," says Dr. Sivaraju. "We map in great detail where the language representation is—meaning the part of the brain that processes language and makes it possible to read, write, and comprehend," he says. "We also map motor and sensory function—the location in the brain responsible for the movement and sensation of your thumbs, hands, legs, elbows, and arms."

What surgical treatments are available for treating epilepsy?

When the brain tissue causing the seizures is identified, there are two types of surgery to eliminate it:

Resection (or cutting out the tissue causing the seizures): This is the traditional surgical treatment. While resection is the most invasive strategy, it's also the best chance for complete freedom from seizures, and even those patients whose seizures aren't eliminated will have a better chance for an improved quality of life. "Resection works best when the surgeon can pinpoint a single clear location in the brain that is not linked to a function," says Dr. Sivaraju.

Several surgical procedures for epilepsy treatment were first developed at Yale, including one of the most commonly used resection techniques for removing parts of the temporal lobe, which is the most common area for seizure disorders. Yale Comprehensive Epilepsy Center co-director and neurosurgeon Dennis Spencer, MD, and his late wife, neurologist Susan Spencer, MD, pioneered the use of electrodes to determine exactly which part of the temporal lobe the seizures were originating from, followed by surgery to remove only that area.

"We are now able to look at those patients over 30 years and find that the outcomes are very good," says Dr. Spencer. "Patients who are good candidates for temporal lobe resection have a 75% chance of fully controlling their seizures."

Laser ablation to destroy the abnormal tissue: Laser ablation, also known as thermal ablation, is less invasive than resection (although it still uses general anesthesia and a probe placed into the brain in the area to be ablated). It can be effective for patients whose seizures emanate from a small region of the brain in a specific location that is easy to access and target.

This approach uses real-time intraoperative high-resolution MRI

guidance to insert a small probe through a tiny hole in the skull to deliver a set amount of energy to the area that will be treated. The energy is changed to heat that burns away the tissue causing the seizures. (Yale has a dedicated MRI scanner in a specialized operating suite for these types of procedures.)

Laser ablation does not offer the same cure rates as resection, but it has a lower risk of side effects, requires a shorter hospital stay, and offers a quicker recovery. Dr. Sivaraju says the "seizure freedom" rate from laser ablation is about 60% compared with 70% or 75% for similar cases treated with resection. In some cases, laser ablation is performed first, and resection is planned if the seizures continue.

What if the origin of the seizures isn't clear enough for surgery?

A third option, called neurostimulation (or neuromodulation), involves implanting devices in the body to control the seizures. Scientists have known for decades that seizures can be silenced using stimulation to the cerebral cortex, the portion of the brain responsible for such functions as consciousness, thought, memory, language, and personality.

Neurostimulation is considered when surgery or laser ablation is too difficult or risky, often because a clear focal point of seizure origin does not exist or can't be identified. It is also considered when the region of seizure onset overlaps with important functions and, therefore, cannot be removed or ablated with a laser. "Before, when the medications didn't work and we thought a patient wasn't a good candidate for surgery, there were no other options," says neurologist and epileptologist Imran Quraishi, MD, Ph.D. "Now, pretty much anyone with refractory seizures can benefit from some type of neuromodulation."

An implanted device works like a dimmer switch that lessens the intensity and frequency of seizures and sometimes stops them before they start, Dr. Quraishi explains. "For most patients, the seizures still happen, but generally they'll be milder and less frequent than before."

The rate of complete freedom from seizures is lower than with resection or laser ablation, and most patients also continue to take medication to treat the seizures. "If you put devices in a hundred patients, over time, at least 70 of them would have a 50% reduction in their seizure frequency," Dr. Quraishi says. "Neurostimulation can make a significant difference."

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