A cut above: surgical interventions for epilepsy

Functional neurosurgeon Dr Alastair Hoyt talks to International Innovation about his fascinating work on the surgical treatment of epilepsy to reduce debilitating symptoms and preserve neurological function.

Could you begin by explaining what led you to pursue a career as a functional neurosurgeon?

While all types of neurosurgery benefit patients, I find the treatments a functional neurosurgeon provides are particularly rewarding, as they often represent a restoration of function, which allows patients to participate in a full life. Many of the diseases a functional neurosurgeon treats, such as epilepsy and Parkinson’s disease, also benefit from multidisciplinary management, and I enjoy working within a group of diverse professionals. It is an important reminder to me that being a neurosurgeon doesn’t make me the smartest person in the room, just the one who is trained to operate.

Why are surgical interventions for epilepsy of particular interest to you?

Epilepsy is a debilitating disease, robbing otherwise neurologically normal people of their independence and jeopardising their safety. Epilepsy surgery has proven to be an effective tool in reducing or eliminating seizures, while avoiding severely adverse effects.

Mesial temporal lobe epilepsy is, in many ways, the prototypical case for surgically treatable epilepsy. It is among the most common forms of epilepsy, is least likely to respond to treatment with medications, and tends to benefit greatly from surgery. In carefully selected patients, most authors report that around 80 per cent can be free of seizures after surgery.

How do you assess whether an individual is a suitable candidate for epilepsy surgery?

The evaluation process is complex and involves input from many different medical disciplines. The first step is recognising that a person is suffering from seizures, which can be particularly difficult in children. Most cases of epilepsy can be controlled with medications, but if a patient fails two different anti-epileptic drugs (AEDs), they should be referred to a comprehensive epilepsy centre for surgical evaluation.

The process of evaluation is tailored to each patient, but basic tests involve inpatient video electroencephalogram monitoring, high-quality magnetic resonance imaging of the brain and neuropsychological testing. A variety of other functional and imaging tests can also be of help. Ultimately, the preponderance of the evidence must support a surgical plan that has a good chance of eliminating seizures while preserving the patient’s neurological function.

Is there a specific age at which surgical interventions for epilepsy are more likely to be effective?

It is difficult to draw broad conclusions as to the optimal time for surgical intervention, but irrespective of the age at which epilepsy develops, there is strong evidence to suggest that earlier surgical treatment results in better outcomes for many patients. There are also studies that demonstrate the associated economic benefits. Surgery can be effective in both children and adults, but some argue particularly for surgical treatment of paediatric epilepsy, as opposed to waiting for the patient to reach adulthood. Unmitigated seizures and long-term use of AEDs have deleterious effects on the developing brain’s function.

Children also have the remarkable ability to reorganise brain function after surgery which, in essence, makes them better at ‘healing’ neurological insults than adults. Unfortunately, studies from large centres suggest that most patients are not evaluated for epilepsy surgery until more than 15 years after diagnosis.

You have recently taken up a post at Marshall University in West Virginia, USA. What does your role there entail?

While I treat a variety of conditions, a major goal is to develop a comprehensive surgical epilepsy centre with my colleagues in neurology, neuropsychology, radiology and other medical specialties. We aim to bring world-class epilepsy treatment to the people of the region. As it is an academic centre, we also plan to participate in research to advance understanding of epilepsy and its treatment.

Finally, what obstacles must be overcome if surgical intervention is to be made more widely available for epilepsy patients?

There are a number of obstacles. First, developing a surgical epilepsy programme requires a substantial number of resources, both in terms of facilities and expertise. Second, more doctors need to be educated on the capabilities and limitations of modern epilepsy surgery.

Most importantly, patients themselves need to be able to learn about the options available. They need access to information and should speak with people who have undergone similar surgical procedures. Brain surgery is a frightening concept, but it may be more beneficial and less intrusive than some patients might imagine.
Minimising risk, maximising efficacy

Reducing seizure incidences while preserving neurological functionality is paramount to epilepsy treatment, and developments in technology are increasing the efficacy of and opportunity for surgical procedures. Now, Marshall University in West Virginia, USA, is developing a comprehensive epilepsy centre to increase awareness and understanding of what is involved.

IT WAS HIPPOCRATES who first suggested that epilepsy is not a supernatural event but a disease that stems from a ‘natural cause’, which would one day be understood. He was partly right; although modern science has disproved theories associating epilepsy with divinity, no cause can be found in over half of epilepsy cases. A highly debilitating condition that affects the brain and causes seizures (where abnormal bursts of neurons create electrical impulses), epilepsy is one of the most common neurological diseases, with an estimated 50 million people affected worldwide.

Treatment for epilepsy varies greatly from person to person, and usually commences only after a second seizure has occurred, as one event is not a reliable indication that an individual has epilepsy. The majority of epileptics will be prescribed anti-epileptic drugs (AEDs) in an effort to manage the condition and prevent seizures from occurring. However, there are a range of side effects associated with AEDs, and it can be difficult to get the balance right between maximising the control of seizures and minimising the adverse effects.

Although AEDs are highly effective at keeping epilepsy under control for the majority of epilepsy patients, some require alternative interventions. Additionally, the long-term use of AEDs can cause harm to the developing brain, especially in paediatric cases.

SURGICAL INTERVENTION

When medications alone fail to control epilepsy, surgery becomes an option to help manage seizures. In the most common form of epilepsy surgery, the region of the brain responsible for the seizures, known as the epileptogenic zone, is resected. However, accurately locating this zone can be problematic. When less invasive diagnostic tests are inconclusive, electrodes can be placed inside the skull to record and analyse electrical activity in the brain between and during seizures, thereby detecting the epileptogenic zone. However, as Dr Alastair Hoyt, a functional neurosurgeon at Marshall University’s Joan C. Edwards School of Medicine explains, the procedure involves some acute challenges: “Placement of such electrodes carries risks, including infection, bleeding, or injury to the very brain we are attempting to protect and treat”. Moreover, it is sometimes difficult to anchor the electrodes in a stable position inside the brain during longer-term monitoring.

In order to address these issues, a multidisciplinary team from Marshall University is investigating ways to improve the standard of current procedures in the hope that surgery becomes a more viable and less risky method of eliminating seizures. Based on work undertaken during his training, Hoyt has recently submitted a paper that details a surgical procedure using laser thermal ablation to treat epilepsy.

RISK REDUCTION

The patient was a 17-year-old boy who suffered from a wide range of symptoms related to epilepsy, including migraine headaches and near-daily disruption to his vision. After initial MRI images of a patient with a large arachnoid cyst and epilepsy before and after intracranial electrode placement.
treatment, he enjoyed five months of seizure freedom and was able to play baseball again. However, after experiencing further seizures, he underwent a second round of awake ablation to target the remaining heterotopic grey matter just above the ablation cavity. There was a marked reduction in the frequency of episodes and a total elimination of the more debilitating generalised events.

Surgically treating lesional occipital lobe epilepsy with minimal risk is possible and could become an effective means of eliminating or reducing seizures in certain patients

Three factors of the report are of particular interest to those trying to find a means to reduce seizures while preserving neurological function. First, the team used magnetic resonance image-guided laser interstitial thermal therapy to destroy the epileptogenic zone, which gave the neurosurgeons greater control, whilst minimising the effect on the patient. Indeed, on both the initial and repeat treatments, the patient was released from hospital the day after surgery. Second, intraoperative awake functional testing was used to provide guidance to the surgeons, whilst significantly reducing the risk of damage to the nervous system. While this technique has been used before, this was the first time that awake functional testing had been used during MRI-guided laser interstitial thermal therapy. Third, magnetoencephalography was used to help identify the precise location of the epileptogenic zone, obviating the placement of electrodes in the patient’s brain.

Ultimately, both the initial and repeat procedures demonstrate that surgically treating lesional occipital lobe epilepsy with minimal risk is possible and could become an effective means of eliminating or reducing seizures in certain patients.

THE EARLY BIRD

Children with epilepsy often have seizures that are difficult to control and, as in adults, there are cases for which AEDs have proven ineffective. Studies have repeatedly shown that in these circumstances, the earlier the surgery is performed, the better the outcome. Hoyt and his colleagues recently described the case of a four-year-old girl suffering from seizures and a large arachnoid cyst, with a degree of success. “The young lady did well after a surgery to remove part of the frontal lobe, and the frequency and severity of her seizures decreased significantly,” Hoyt explains. “While she tolerated the treatment well and benefited from surgery, she continued to suffer from some seizures. Her story reflects both the success we enjoy with epilepsy surgery and the shortcomings of current treatment approaches.”

Ultimately, the challenge faced by functional neurosurgeons is to provide surgical treatments that are so effective as to completely stop seizures and enable the patient to navigate life more easily. Fortunately, technological advances are significantly increasing the success rates of surgical intervention: “The last several decades have seen a tremendous improvement in imaging technology and our ability to evaluate patients with epilepsy,” reveals Hoyt. “While I expect this trend to continue, I also believe that more innovative treatments will be refined. Traditionally, surgery entailed removal of the tissue causing seizures, but new technologies are allowing for disconnection or destruction of that tissue with less invasive procedures, such as thermal or ultrasound ablation.”

The opportunities to treat epilepsy with surgery are on the increase and, with the establishment of academic centres such as the one at Marshall University, a correlation between those opportunities and better understanding of epilepsy treatments can be established. It is likely new techniques will be created, as Hoyt elucidates. “I expect the continued development of ‘modulation’ techniques, in which an electrical stimulator is placed in the brain to prevent or terminate seizures when they occur, in much the same way modern pacemakers work in the heart”. It is clear that the future could one day consign epileptic seizures to the past.

SUGICAL TREATMENT FOR EPILEPSY

OBJECTIVES
• To develop a comprehensive and multidisciplinary surgical epilepsy centre
• To advance the understanding and treatment of epilepsy
• To offer epilepsy treatment to those in rural and low-income settings

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DR ALASTAIR HOYT earned his medical degree from the University of Nebraska’s College of Medicine, USA, in 2001. He completed his neurosurgery residency at the Medical College of Wisconsin, USA, in 2012 and a stereotactic and functional neurosurgery fellowship at the Barrow Neurological Institute, USA, in 2015. Hoyt is currently Assistant Professor of Neurosurgery at Marshall University’s Joan C. Edwards School of Medicine.