Surgery In The Treatment of Epilepsy

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Introduction

In developed countries, 70% to 80% of epileptic patients can be adequately controlled using modern antiepileptic medication protocols. Within that group of patients who are inadequately controlled on medication there are many who are potential candidates for surgical treatment that can offer the possibility of complete freedom from seizures. The evaluation of the patient requires a multidisciplinary approach within a dedicated unit that has the facilities to address the many neurological, imaging, neurophysiological, surgical and psychosocial issues involved in the care of the patient.

The concept of surgery for the treatment of epilepsy dates back over 100 years to the resection of a cortical scar by Victor Horsley in 1886. Following the introduction of the EEG and the identification of ictal EEG abnormalities surgery for epilepsy progressed in a few centres in North America and Europe, notably under Wilder Penfield in Montreal. However, attempts at surgical treatment in isolated centres where there was a limited understanding of the complexities of involved in the physiology of epilepsy resulted in a plethora of poor surgical results. This led to an attitude of conservativism about surgery in the treatment of epilepsy amongst neurologists, and in many instances this attitude still prevails. During the mid -1980's the modern improvements in neuroimaging and the use of computerised EEG- video monitoring resulted in a significant improvement in the understanding of what can be done for the patient. There are now many centres in the developed world that offer surgery as a second arm in the management of epilepsy. The beneficial effect of surgery in carefully selected patients has been well documented and is now beyond dispute.

It is estimated that in a population of 50 million people there will be as many as 28000 patients who could benefit from epilepsy surgery.

Intractable Epilepsy

Because of the diversity of the human experience it is not possible to lay down rigid criteria for the determination of medical intractability of epilepsy. Yet it is intractability that is a prerequisite in the evaluation of patients for the surgical treatment of epilepsy. Criteria that must be considered relate to seizure type and frequency, the many issues that relate to previous medical therapy, as well as the psychosocial, educational and employment consequences of the patient's epilepsy. In the final analysis it is a matter of asking if surgery is able to offer a patient a better quality of life when the risks and benefits of surgery are carefully considered. The epilepsy unit team must look beyond the practicality of surgery to a careful evaluation of the psychological and social implications of the consequences of the planned surgery and to the expectations of the patient and the patient's family and caregivers.

Investigation of Intractable Epilepsy

A thorough understanding of the specific physiology of the patient's epilepsy is essential to the success of any surgical endeavour. Various considerations are essential to this understanding and may be defined in terms of the following "zones". The Epileptogenic Zone, Epileptogenic Lesion, Irritative zone, Pacemaker zone, and the Ictal Symptomatogenic. Any failure to elucidate these regions during the investigation of the patient will result in failure of the surgery.

Cortical Zones in Epilepsy Physiology

Epileptogenic Zone:
That region of the cerebral cortex that generates the epileptic seizure. Total ablation of this area should result in freedom from seizures.
Irritative Zone
Cortical region that generates interictal epileptiform discharges seen on EEG.

Pacemaker Zone
Cortical region from which clinically evident seizures develop.

Epileptogenic Lesion
The structural abnormality that is associated with the seizure abnormality.

Ictal Symptomatogenic Zone
Cortical region associated with the initial seizure symptomatology.

Seizure Semiology

The Neurologist, when assessing a patient with epilepsy obtains a detailed account of the seizure pattern from the patient and close associates. This description of the seizures is the first step in understanding the nature of the condition and dictates the planning of further investigation of the condition. Video monitoring of the patient in the epilepsy monitoring unit supplements the information obtained from the patient and family.

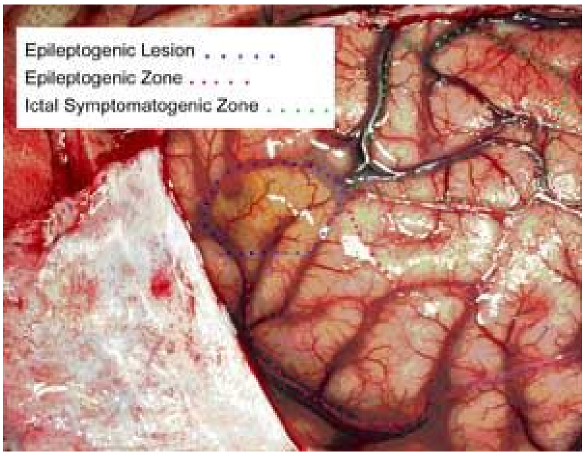
Magnetic Resonance Imaging (MRI)

An MRI of the Brain is an essential early step in the investigation of the patient as it can display fine anatomical detail. A neuroradiologist who has a thorough understanding of the neuroimaging of epilepsy should conduct this investigation. The parameters used in the investigation of epilepsy are not those of a routine MRI scan. The dedicated MRI protocol should be directed at displaying temporal lobe abnormalities as well as subtle cortical abnormalities that are easily overlooked.

Scalp EEG Monitoring

Most patients who suffer from intractable epilepsy will no doubt have had many standard EEG studies in the course of their previous management. These investigations do not provide the detailed information that is required in the work-up of a surgical candidate.

Patients are admitted to the epilepsy unit where continuous video and EEG monitoring takes place. The seizure experienced by the patient can thus be seen by the epileptologist when the video recording is studied and this can be correlated with the continuous EEG that is stored in a fixed time sequence with the video system. This video-EEG recording may continue for many days before sufficient information is available to the neurologist. It is preferable to capture a number of seizures during this investigation.



EEG VIDEO MONITORING UNIT.

The patient is connected to a continuous EEG that is computerised and integrated with a continuous video system. {The Unit accommodates 6 beds, each with an independent computer system within an open-plan ward that is arranged for easy surveillance by nursing staff.}

Neuropsychological Assessment

Neuropsychological assessment provides an objective evaluation of the cognitive function of the patient in terms of concentration, language, auditory and visual memory as well as executive and visuospatial function. The primary goal of this assessment is to determine the site of any disturbance based on the typical organisation of cerebral function. When an area of dysfunction is identified it may indicate the possible localisation of the epileptogenic zone. This information, whilst not diagnostic in its own right, may be used to complement, contradict or confirm the findings from other modes of investigation such as electroencephalography and neuroimaging. Secondly, neuropsychological assessment provides a baseline of cognitive functioning against which postoperative functioning can be measured. The assessment is also used to identify a patient's specific strengths and weaknesses that can be used during guidance concerning issues of employment and education. A full neuropsychological assessment also includes a clinical evaluation in order to identify any depression, anxiety or other psychological or psychosocial factors, that may interfere with successful recuperation following surgery.

Sodium Amytal Test (Wada Test)

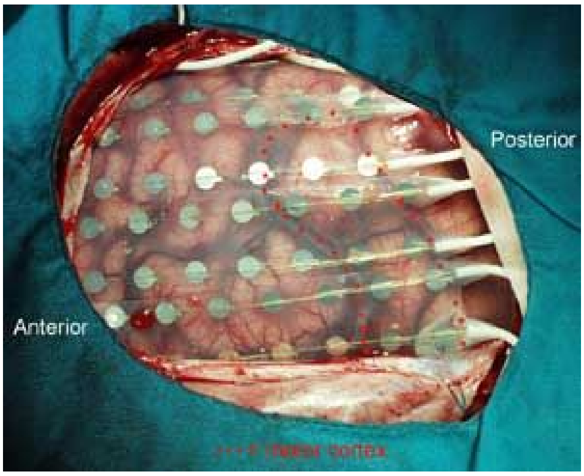
If a discrepancy between the neuropsychological assessment and other parameters such as the EEG and Neuroimaging studies occurs, atypical cerebral organisation may be present. An intracarotid sodium amytal test may then be performed in order to determine the lateralisation of cerebral function. By injecting a rapid acting anaesthetic via a catheter placed in one internal carotid artery the ipsilateral cerebral hemisphere can be "shut down", leaving the contralateral hemisphere available to memory and language function assessment. It is thus possible to lateralise the tested functions.

Subdural Electrode EEG Monitoring.

In the event that scalp EEG monitoring and MRI fail to provide sufficient evidence for the planning of surgery, the patient may require more precise EEG evaluation by placing the recording electrodes directly over the surface of the cerebral cortex. These electrodes are generally applied in the form of electrode strips that may carry as many as 8 contact points at 1cm. intervals or as grids that carry up to 64 contacts. Inserting the electrodes involves either appropriately placed burr holes or a formal craniotomy. The planning of the electrode placement is dependent upon the individual clinical picture dictated by the preceding investigations such as seizure semiology, MRI scan, EEG-video monitoring, and neuropsychology. The electrode leads are brought through the scalp and fixed in such a manner as to reduce the risk of electrode displacement and CSF leakage. After placement of the subdural electrodes the patient is returned to the monitoring unit where EEG and video data is collected on a continuous basis for up to three weeks.

The subdural electrodes can also be used as stimulation points for evaluating cortical localisation of motor and language function.

X-ray of skull showing position of multiple subdural electrode strips.



Subdural electrode grid placed over central cortex. The motor cortex was identified by stimulating the electrode points while the patient was in the ward, and later confirmed by intraoperative cortical stimulation.

Single Photon Emission Computed Tomography (SPECT Scanning)

During the 1980's it was noted that SPECT Scans performed during or soon after a seizure demonstrate altered cerebral blood flow in the region of the epileptic focus. It is essential to inject the isotope used in the scan, at the time of the seizure or shortly thereafter. While data collection on the SPECT camera must be performed within two hours of the injection. This can present logistical problems and the investigation is not an essential part of the patient work up but can be used to augment other studies. The investigation yields 70% to 100% accuracy in respect of the lateralisation of known temporal lobe epilepsy. However, SPECT cannot be seen as a substitute for intensive video-EEG monitoring, in the preoperative work-up for epilepsy surgery.

Proton Magnetic Resonance Spectroscopic Imaging (MRS)

MRS acquires the spectra of magnetic resonance of nuclei other than water, as is the case with the conventional MRI. MRS is non-invasive, does not use isotopes and can be performed in conjunction with the MRI studies that are routinely used in epilepsy units. MRS-detected lactate elevation in post-ictal studies has the potential to localise seizure foci and to assist in the planning of subdural electrode placement. This recent development is still undergoing clinical evaluation but has the potential to become an important component of the epilepsy investigation.

Positron Emission Tomography (PET)

Because epilepsy is primarily a functional disturbance of the brain, functional neuroimaging techniques are well suited to investigation of the condition. PET tracers can be used as markers for receptors and neurotransmitters as well as other metabolic activity. However the current cost of PET scanners preclude their routine use in most epilepsy units.

The Objective of Surgery.

The objective of the surgical team should be to improve the psychosocial status of the patient who has medically intractable epilepsy. In order to achieve this the team must reach a conclusion concerning the likely benefit in respect of seizure control and the risks attendant upon the invasive monitoring and planned surgical resection. It is vitally important that the patient as well as the caregivers appreciate the risks and potential benefits of surgery. Discussions on these issues should go beyond the simple evaluation of seizure benefit but should include the functional consequences of any surgery as well as an evaluation of the expectations of the patient and care givers. As in all functional neurosurgery, unrealistic expectations on the part of the patients and their supporters must be avoided at all cost.

The various surgical options depend upon a thorough understanding of the particular physiology of the patient's epileptic condition. This understanding is a sine quo non to the success of surgery and relates not only to the identification of the cortical zones that play a part in the seizures but also the functional consequences of the planned intervention.

Referral to Epilepsy Unit

If a patient has suffered from intractable Epilepsy for more than two years and has been given a thorough trial of available anti-epileptic medication, that person should be given the opportunity to be assessed by a neurologist that fully understands the benefits of the surgical treatment of epilepsy. This presupposes that the neurologist will be working in close cooperation with a neurosurgeon who has taken an interest in this form of neurosurgery. The surgery for epilepsy is very much a team effort and involves neurologists, neuroradiologists, EEG technicians, neuropsychologists, neurosurgeons counsellors as well as nursing staff that have gained experience and training in an epilepsy unit.

In some instances there may be doubt about the existence of true epilepsy in a patient who has repeated seizure-like events that do not respond to antiepileptic medication. These events may be categorised as nonepileptic seizures or psychoseizures. (It is estimated that in a population of 50 million people there may be as many as 15000 people who suffer from a nonepileptic seizure abnormality that is misinterpreted as refractory epilepsy and are on unnecessary chronic antiepileptic medication.)

Indications for Admission to EEG-video Monitoring Unit

Inractable Epilepsy

Conrolled Epilepsy where medication produces unacceptable side effects

Epilepsy with a known surgical lesion

Where there is diagnostic doubt about the true existence of epilepsy

Temporal Lobectomy

Complex Partial Epilepsy of Temporal lobe origin accounts for a high proportion of cases amenable to surgical treatment with a high expectation of a surgical cure of the seizure abnormality. As many as 70% of patients receiving temporal lobectomy can hope for a cessation of epilepsy without the need for continued antiepileptic medication. A further 10% will be seizure free, but require medication.

The overall prognosis for individuals with complex partial epilepsy is such that about 25% of patients will be refractory to medication. The most important predictor of success of medical treatment is an early beneficial response to antiepileptic medication. Predictors of a poor response to medical treatment include seizure onset under 2 years of age, frequent seizures, secondary generalisation of seizures, a history of febrile convulsions during infancy and status epilepticus. A known pathological lesion within the temporal lobe such as mesial temporal sclerosis, cortical dysplasia, or a benign tumour also predict a poor outcome for medical treatment and present indications for referral to an epilepsy surgery unit as there is a high probability of a good outcome in these patients.

The inherent functional risks related to temporal lobectomy include language (dominant hemisphere) and memory disturbance. The preoperative investigation is able to highlight these risks in the particular patient. If memory function is found to predominate in the temporal lobe from which the seizures originate, temporal lobectomy is contraindicated as profound anterograde memory dysfunction may occur. In the event of language function occurring in the temporal lobe to be resected, awake craniotomy with functional cortical mapping for language can be performed with minimal additional inconvenience to the patient. This procedure makes it possible to avoid injury to the language mediating neocortex. In some instances it may be necessary to modify the surgical procedure to the more restricted procedure of selective amygdalohippocampectomy, with preservation of the temporal neocortex that is involved with language function.

TESTING LANGUAGE FUNCTION DURING AWAKE CORTICAL MAPPING

The patient is asked to name common objects
while cerebral cortex is receiving electrical stimulation.

Extratemporal Cortical Resection.

When the seizure activity originates from non-eloquent areas of frontal, parietal and occipital lobes, resection of the affected neocortex can be performed with relative safely and the results of surgery may be comparable to that which can be obtained in the case of temporal lobe surgery. In some instances functional motor mapping will be required when the resection is close to the central region.

Cortical resection and the resection of small lesions may be facilitated by the use of neuronavigation techniques. Information acquired from the MRI is transferred to a workstation and infrared camera system in the operating room that integrates the position of the exposed brain with the MRI display on the workstation. The surgeon is able to use the MRI display to assist him in navigating to the planned target area.

Functional Hemispherectomy

Hemispherectomy for epilepsy due to non-dominant hemispheral abnormalities in young children with infantile hemiplegia was popularised by Krynauw in the 1950's. Years later the late morbidity of the operation due to cerebral haemosiderosis became apparent and the operation was largely abandoned. Various modifications to the operation have been attempted. This led to surgery being directed at limited tissue resection of the temporal lobe and central region but disconnection of frontal and occipital lobes as well as corpus callosotomy. This effectively produces a functional hemispherectomy, while eliminating the problems of haemosiderosis that occurs with massive tissue resection. The indications for functional hemispherectomy have now been extended to include children suffering from the progressive chronic encephalitis of Rasmussen, Sturge-Weber Syndrome and Hemimegancephaly. These patients suffer from intractable epilepsy due to unilateral cerebral pathology; they are hemiparetic, show evidence of mental retardation and often manifest poor impulse control and aggressive behaviour.

Seizure control in these patients can be achieved in 70% to 80% of patients, while many demonstrate an improvement in behaviour and intellectual function, with no significant deterioration in motor function after the surgery.

Corpus Callosotomy

Corpus Callosotomy involves the complete or partial section of the corpus callosum thus effecting a disconnection the cerebral hemispheres. The procedure is particularly beneficial in those children who suffer from atonic drop attacks with an expectation of significant improvement in over 80% of cases. Surprisingly, the operation does little to hinder the patient during activities of daily living although numerous neuropsychological studies have demonstrated problems with interhemispheric information transfer.

Multiple Subpial Transections.

Multiple vertical transections through the cortex leave the vertical columnar arrangement of fibres largely intact thus preserving most incoming and outgoing neural activity while disrupting the lateral fibres within the cortex. As epileptic activity extends horizontally within the cortex, the multiple subpial transactions have the effect of isolating areas of cortex and reducing the spread of seizure activity. The procedure is performed in such a way as to preserve the cortical vasculature. In cases where the epileptogenic zone lies within eloquent areas such as sensorymotor cortex or the language area, cortical resection is contraindicated but multiple subpial transections remains a surgical option.

Vagus Nerve Stimulation (VNS)

Vagus nerve stimulation involves placing an electrode system over the left vagus nerve in the neck; this is connected to a pulse generator that is buried subcutaneously in the pectoral region. It is believed that stimulation of the vagus imparts afferent stimuli to the various cerebral connections associated with the vagus and that this disturbs the mechanisms responsible for seizure activity. The exact neurophysiological mechanism is not known. Vagus nerve stimulation reduces seizure activity by 50% in about one third of patients treated in this manner. The surgery carries little risk to the patient but seldom results in complete cessation of seizures.

CONCLUSION

Recent advances in the neuroimaging, EEG technology and surgical armamentarium as well as the concept of the multidisciplined epilepsy unit men that there is now a great deal more that can be done for epileptic patients who are not adequately controlled by medication alone.