

Review of Epilepsy Surgery and its Practical Applications

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Abstract: *Background:* Epilepsy is a very disabling problem which has a great impact on economic, social and psychological aspects of affected individuals. Epilepsy surgery is the most effective way to control drug resistant cases often leading to improvement in cognition, behavior and quality of life. The efficacy of epilepsy surgery depends on the type, underlying pathology and the accurate localization of epileptic focus by various modalities. *Aims and objectives:* To briefly review the inception of epilepsy surgery, various indications of epilepsy surgery, pre-op evaluations and the various techniques available. *Conclusion:* Epilepsy surgery play a major role in intractable cases and often improve quality of life if timely intervention is done. A better understanding of the pathophysiology of these epileptic syndromes amenable to surgery, and refinements in surgical techniques have all contributed to better outcomes following surgery

Keywords: epilepsy, functional anatomy, Intractable, Hemispherectomy, EEG

1. History

Sir Victor Horsley was the first person to perform the surgery for epilepsy in London in 1886. Modern methods to localize the epilepsy were first pioneered by Penfield and Jasper at Montreal Neurological Institute using EEG (Electro-encephalography). Localization of seizure activity together with functional anatomy of brain and documented evidence of medication failure are pre-requisites for epilepsy surgery.^{1,12,16}

Davidson and Falconer demonstrated in 1975 that early surgery gives maximum results in temporal lobe epilepsy. the contention was to prevent persistence of focal seizures into adulthood. The variety of seizure presentations is very much varied and presented with different childhood syndromes. Because of this fact, novel approaches are required to define the indications for surgery. By the use of new modalities of electro-physiological methods and imaging methods, the indications are more well defined and modern surgical techniques have made possible to treat cases which were previously rejected^{2,24}.

2. Demography

The prevalence of epilepsy is estimated to be about 1%. Epilepsy is often operationally defined as two unprovoked seizures occurring more than 24 hours apart. Up to 40% of epilepsy patients have medication-resistant or medically intractable seizures. As many as half of these patients are candidates for curative or palliative epilepsy surgery^{3,5,17}.

Role of surgery in epilepsy: Quality of life improves significantly after successful surgery. The degree of success of epilepsy surgery depends largely on careful pre surgical evaluation for identification and selection of the most appropriate candidates^{3,9,10}.

Indications^{8,12,35}

- 1) Persistent Seizures- despite adequate pharmacological treatment
- 2) Drug resistant epilepsy: It is defined as a failure of adequate trials of two tolerated and appropriately chosen and used anti-epileptic drug (AED) schedules (whether as mono-therapies or in combination) to achieve sustained seizure freedom.
- 3) Medically Intractable Epilepsy
- 4) Epilepsy not controlled by 2 or more appropriate AEDs in optimal dosages
- 5) Adults (16years and above) who continue to have seizures even after 2 years of treatment
- 6) Pediatric epileptic syndromes

Natural course of intractable seizure^{15,18,23}:

It was Ounsted and Lindsay who prospectively studied cases and concluded that by adulthood 33% had remissions thus concluding the importance of performing early surgery. Syndromic cases are frequently referred for surgical interventions whereas others are often managed conservatively. Sturge-Weber syndrome is one such example. With wide area of involvement, Hemispherectomy results in superior recovery of cognitive and behavioral functions. Tuberous sclerosis, surgical excision of tubers gives excellent results. Hemimegalencephaly is associated with early onset of seizures and hemispherectomy often helpful to promote neuro-development. Rasmussen syndrome characterized by chronic focal encephalitis often is a cause of focal seizures. Initially presents as "epilepsia partialis continua" or status epilepticus, it often has rough course with hemiparesis and uncontrolled seizures.

Predictors of intractable seizures^{16,28,29}:

Patients with partial complex seizures along with generalised seizures and a structural lesion can be considered as intractable only after 1 year of medical management. Patients with prolonged febrile seizure during infancy often have later onset of partial seizures. These cases usually have hippocampal sclerosis. the association of early onset of seizures along with structural pathology often predicts intractable nature of seizures.

Pre surgical evaluation^{26,27}

Careful and knowledgeable pre-surgical evaluation of candidates of epilepsy surgery still remains the most important step. A principal aim of pre-surgical evaluation is to determine the epileptogenic zone and the relationship of this zone to eloquent areas of the brain. The epileptogenic zone is the area of the brain which gives rise to seizures, and the removal of which results in the patient becoming seizure free.

Pre surgical evaluation may be non-invasive or invasive^{10,19,23}.

Phase I—Non-invasive Investigations

Non-invasive evaluation is done in all patients that include the following tests.

Routine Electroencephalographic Recording(EEG)

Routine EEG findings are positive in 50% to 60% of patients with epilepsy, and the yield is increased by repeated or prolonged recordings that sample drowsiness and sleep.

Continuous Video-Electroencephalographic Recording

Continuous computer-assisted video-EEG monitoring has become the mainstay of localization of the zone of

epileptogenesis. This is usually done continuously (24 hours a day), and may last from a few hours to several days (in the hospital), depending on the time needed to record seizures.

Video – EEG monitoring achieves the following:

- 1) It confirms the diagnosis of epilepsy (it is the only way to make a positively certain diagnosis of epileptic seizures).
- 2) It distinguishes between partial (or focal) epilepsy, where seizures are localized at onset, and generalized epilepsies, where seizures arise from the whole brain.
- 3) If seizures are localized, it usually allows to pinpoint the zone of seizure onset, which is very important for surgery.

Imaging of the Epileptogenic Zone(EZ)^{25,26}

Brain MRI - is the neuroimaging modality of choice for the pre-surgical evaluation of patients for epilepsy surgery. Hippocampal sclerosis, the most common pathology associated with temporal lobe epilepsy, is well diagnosed on MRI. Most patients with epilepsy have had normal MRIs, but subtle abnormalities are often found when MRI is performed specifically for epilepsy surgery (for example “mesial temporal sclerosis”).

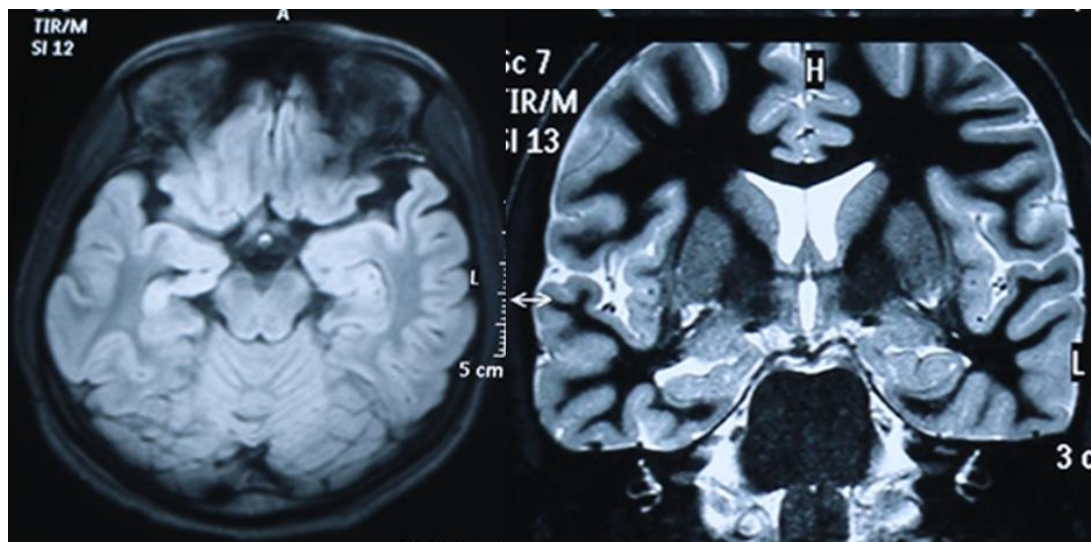


Figure 1: MRI Brain(Axial- FLAIR and Coronal T2) showing sclerosis of the right medial temporal lobe (uncus, hippocampus and amygdala)

Functional imaging^{31,36}

It is done with Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT) - offer information about ictal or interictal brain tissue metabolism. PET using 18 - fluorodeoxyglucose (FDG) typically shows regional hypometabolism around the EZ when the tracer is injected inter-ictally.

Neuropsychological Testing^{21,15}

Detailed neuropsychological testing is performed as part of the pre-surgical evaluation. Its goals are to identify epilepsy-related cognitive impairment, and it therefore complements EEG and neuroimaging in localization and lateralization of the EZ.

Phase II - Invasive evaluation^{29,31}

This is only used when the above tests fail to pinpoint the location of seizure onset with enough confidence. Only about 10% of surgery candidates require this phase. It involves placing electrodes inside the skull (directly in contact with the brain) over a specific region of the brain. Various techniques are available (depth, epidural, subdural electrodes).

Indications for invasive monitoring^{33,35}

- 1) Temporal lobe seizures-
 - a) Doubtful side
 - b) Normal MRI
 - c) Bilateral pathology
 - d) Discordant non-invasive testing
- 2) Extra-temporal seizures-
 - e) Definition of extent of epileptogenic area
 - f) Cortical mapping



Figure 2 : (A) Intra OP mapping of eloquent areas of brain with surface electrodes and (B) corresponding EEG waves monitored during surgery

Surgical Approaches for Epilepsy^{2,7,34}:

Curative Palliative



MTLS
Lesional
-Low grade glioma
-Cavernous malformation

Pathologies

non MTLS temporal lobe epilepsy
cingulate epilepsy
malformations of cortical devpt

Procedures

| |
|--|
| Resection |
| Hemispherectomy: resection of the cerebral hemisphere |
| Lobectomy: resection of one cerebral lobe |
| Topectomy: resection of a focal area of cerebral cortex |
| Disconnection |
| Corpus callosotomy: disconnection of two hemispheres |
| Multiple subpial transection: disconnection of a focal area of cerebral cortex |
| Hemispherectomy: disconnection of a cerebral hemisphere |
| Stimulation |
| Vagal nerve stimulation |
| Anterior thalamic stimulation |
| Responsive neurostimulation |

Surgery for epilepsy is performed either with a “curative” or a “palliative” indications. “Curative” aims at complete freedom of seizures by the complete resection of the seizure generating area. “Palliative” aims at an amelioration of the seizure tendency, while seizure-freedom is not expected, although it can occur.

3. Resective Procedures

These procedures are usually associated with an excellent outcome once the EZ is completely removed. These procedures are usually curative in intent.

- 1) **Topectomy/ Lobectomy:** Topectomy refers to excision of a part of brain which is affected by the epileptic pathology.
- 2) **Lobectomy** refers to resection of the affected lobe
- 3) **Amygdalo-hippocampectomy:** It is one of the commonly performed epileptic surgery with excellent outcome. It is performed for medial temporal lobe sclerosis (MTLS), the prototype of a surgically amenable

epileptic syndrome. MTLS is frequent and often drug-resistant epileptic syndrome, the most characteristic feature being the hippocampal sclerosis. Without surgery the prognosis of medically refractory patients with MTLS is relatively poor associated with intractable seizures, loss of memory and psycho social disturbances.

Disconnection procedures: They are usually palliative in nature aiming at ameliorating seizure frequency.

- 1) **Corpus callosotomy:** The corpus callosum is a band of nerve fibres connecting the two halves (called hemispheres) of your brain. A segment of corpus callosum is disrupted so that there is no transmission of impulses across the hemispheres. It is usually done in patients with severe uncontrollable epilepsy, violent falls and serious injury.
- 2) **Functional hemispherectomy:** It is a type of surgery where in a hemisphere is disconnected from rest of the brain. Functional hemispherectomy involves resection of

the temporal lobe and central cortex along with disconnection corpus callosum and frontal and occipital cortices. The success of hemispherectomy depends on the underlying pathology, with excellent. Outcomes expected for pathologies such as Rasmussen's encephalitis and focal infarcts.

- 3) **Multiple sub pial transections:** It is usually performed on lesions located on eloquent areas of brain. It involves multiple horizontal interruptions of the cerebral cortex preventing the seizure spread. Also horizontal transections on the cortex do not damage the vertically running tracts (axons).
- 4) **Vagal nerve stimulation:** It is a new modality of treatment involving placing of an electrode and stimulating the left vagus nerve in the neck. The pathophysiological basis of vagal nerve stimulation seems to be stimulation of autonomic nervous pathways. At surgery the left vagal nerve is used in order to avoid cardiac side effects, and the electrode is placed on the nerve in the neck between the common carotid artery and the internal jugular vein.

Outcome of epilepsy surgery^{14,16,36}:

There are many facets of outcome from epilepsy surgery - seizure control, neuropsychological development, neurological deficits, quality of life and psychosocial adjustment. Over time epilepsy affects a patient's pattern of behaviour and also their social interaction; and these effects may be irreversible. This would suggest that earlier surgical intervention may be beneficial.

Curative surgeries including amygdalohippocampectomy for MTLs have excellent outcome following surgery with more than 90% Seizure free survival. These patients are usually tapered off anti-epileptic drugs completely in few months. Palliative surgeries too are showing promising results in seizure control and improvement in the quality of life. Nearly 70 % cases of children can become seizure free post-operatively.

Complications of surgeries include meningitis, transient dysphasias and hemiparesis, visual field deficits. There is also significant improvement in behaviour and psychological aspects. Improved cognitive abilities and school .the statistical outcome is often affected by pathological lesion, location of focus, and eloquence of the area of brain involved.

Timing of surgical intervention^{8,18,27}: surgery should be considered before puberty before the behavioural and psychosocial deterioration become established. Intractability should be reasonably established by 2 years. Surgical intervention should be considered based on predictors of intractability, psychosocial status and adaptive behaviours. The chances of success rates are higher if the patients are referred with an identifiable lesion with corresponding seizure focus in the non-dominant temporal lobe. Early surgery is contemplated when the conditions associated with epilepsy and the complications of seizures are perceived as intolerable.

4. Conclusion

Thus overall understanding of the patient condition is of utmost important rather than rigid indications in order to achieve best surgical results. Advanced non-invasive diagnostic tools to delineate epileptogenic lesions, High resolution MR imaging along with mapping offunctional areas of brain with fMRI, PET/SPECT have resulted in excellent outcome following surgery.

Finally, a better understanding of the pathophysiology of these epileptic syndromes amenable to surgery, and refinements in surgical techniques have all contributed to better outcomes following surgery. In summary, majority of patients benefit from surgery. The outcome is usually better in patients with short duration of epilepsy before surgery and timely referral for surgery.

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