Epilepsy Surgery versus Gamma Knife Radiosurgery in Management of Mesial Temporal Lobe Epilepsy with Hippocampal Sclerosis.

A systematic review.

submitted for partial fulfillment of the conditions for the Master Degree in Neurosurgery.

By

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AIN SHAMS UNIVERSITY
2017

Abstract:

Mesial temporal lobe epilepsy is the most common form of human epilepsy, and its pathophysiological substrate is usually hippocampal sclerosis (Ammon's horn sclerosis). The disabling seizures associated with mesial temporal lobe epilepsy are typically resistant to antiepileptic drugs but can be abolished in most patients by surgical treatment. MTLE with HS is the most common drug-resistant disorder observed in epilepsy surgery programs. Although being the gold standard treatment for MTLE with HS, ATL remains markedly underutilized. The reasons behind underutilization are multifactorial. One reason is the perceived risks and the fears about open brain surgery. That's why new surgical modalities have been recently developed to provide less invasive alternatives for this surgically remediable disorder. Among these alternatives is gammaknife radiosurgery (GKR) that implies delivery of radioactive cobalt beams to the temporal mesial structures (amygdale, hippocampus and parahippocampal gyrus). The results of GKR were found to be comparable to ATL as regard seizure freedom especially with using high dose therapy (24 Gy). The major advantage of radiosurgery in comparison with open surgery is its minimally invasive nature. Another advantage of radiosurgery is the possibility of better neuropsychological outcomes. In this review, we searched the literature and summarized the available knowledge from literature on the long term efficacy and safety of gamma knife radiosurgery in comparison to temporal lobe epilepsy surgery in achieving seizure control and improving the neuropsychological outcomes in patients with mesial temporal lobe epilepsy with hippocampal sclerosis.

Acknowledgment

First and forever, all thanks to Allah, the most merciful who guided me to complete this work.

I would like to express my sincere gratitude to my advisor, the head of the 3rd unit, ***Prof.Dr.Ashraf Ghobashy*** for his continuous support, patience, motivation, and immense knowledge. I could not have imagined having a better advisor and mentor for me.

I would like to thank ***Asst.Prof.Dr.Ahmed El-Sayed Desouky***, and ***Dr.Mohamed Atef***, not only for their insightful comments and encouragement, but also for their generous kindness and patience.

For all the ***3rd unit staff members***, thank you for teaching me how to be a neurosurgeon. I will never forget the time I spent learning and practicing in this unit and I will be grateful for it all my life time.

Finally, all thanks to my family, who provided me with the all support needed to reach this step in my life.

Contents:

Abbreviations

AChA	**anterior choroidal artery**
ADC	apparent diffusion co-efficient
AEDs	Antiepileptic drugs
AF	aruate fasciculus
AHS	Ammon’s horn sclerosis
ATL	anterior temporal lobectomy
ATLP	asymmetrical tonic limb posturing
CA	cornu ammon
CEPI	Contrast enhanced perfusion imaging
CI	Confidence interval
DWI	diffusion weighted imaging
EEG	Electroencephalography
FCD	Focal cortical dysplasia
FDG-PET	fluorodeoxyglucose positron emission tomography
FLAIR	fluid attenuation inversion recovery
FS	febrile seizure
GFAP	glial fibrillary acidic protein
GKR	gammaknife radiosurgery
HFLA	high frequency-low amplitude
HS	hippocampal scelerosis
ICA	internal carotid artery
ILAE	International league aginest epilepsy
ILF	inferior longitudinal fasciculus
IOFF	inferior occipitofrontal fasiculus
IPI	initial precipitating incident
LGB	lateral geniculate body
LGK	Leksell Gamma Knife
LM	Logical memory
MCA	middle cerebral artery
MRI	magnetic resonance imaging
MTLE	mesial temporal lobe epilepsy
MTG	Middle temporal gyrus
MTR	medial temporal region

MTS	mesial temporal scelerosis
NCTLE	neocortical temporal lobe epilepsy
NNT	Number needed to treat
PCA	posterior cerebral artery
PET	positron emission tomography
PIQ	Performance IQ
rCBF	relative cerebral blood flow
RCT	Randomized control trials
RR	Risk ratio
SAH	Selective amygdalohippocampectomy
SEEG	Stereoelectroencephalography
SPECT	single photon emission computed tomography
SRS	stereotactic radiosurgery
SRT	stereotactic radiofrequency thermocoagulation
STA	stereotactic thermoablation
TC	Transcortical
TATL	transcortical selective amygdalohippocampectomy
TLE	temporal lobe epilepsy
TPR	Temporal pole resection
TS	Transsylvian
TSAH	transsylvian selective amygdalohippocampectomy
UF	uncinate fasciculus
VIQ	Verbal IQ
VNS	vagus nerve stimulation

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Introduction:

Mesial temporal lobe epilepsy is the most common form of human epilepsy, and its pathophysiological substrate is usually hippocampal sclerosis (Ammon's horn sclerosis). It is the most common epileptogenic lesion encountered in patients with epilepsy. The disabling seizures associated with mesial temporal lobe epilepsy are typically resistant to antiepileptic drugs but can be abolished in most patients by surgical treatment (1).

MTLE with HS is the most common drug-resistant disorder observed in epilepsy surgery programs, accounting for 17%–31% of surgical procedures for epilepsy (2).

Histopathological hallmarks include neuronal loss, atrophy of the hippocampus, segmental loss of pyramidal neurons, granule cell dispersion and reactive gliosis. Pathogenetic mechanisms underlying this distinct hippocampal pathology have not yet been identified and it remains to be resolved whether AHS represents the cause or the consequence of chronic seizure activity and pharmacoresistant TLE (3).

With the advent of EEG, it eventually became clear that psychomotor seizures originated in limbic structures, namely, the hippocampus, the parahippocampal gyrus and the amygdale.

The EEG also made it possible to localize temporal lobe epileptogenic abnormalities for surgical resection (4), which in turn provided opportunities to elucidate the role of hippocampal sclerosis. Although many patients with this disorder had a history of complicated febrile convulsions, supporting a conclusion that hippocampal sclerosis is the result of epileptic seizures, it also became apparent that patients usually became seizure free following removal of this lesion, suggesting that it might also be the cause of epilepsy (5).

MTLE with HS has a characteristic clinical features usually starting in teenagers or even early adulthood with an early history of complicated FS within the first 5 years of life and sometimes positive family history of epilepsy. Patients usually have an aura- preceding the complex partial- seizures of characteristically rising epigasteric sensation, although others may experience emotional, autonomic, olfactory or gustatory sensations. The complex partial seizures typically begin with motor arrest and staring, followed by oro-alimentary automatisms and other purposeless movements. Postictally, patients usually have amnesia of the event and a period of confusion (1).

Surgery is considered a highly effective treatment for medically refractory epilepsy. In temporal lobe epilepsy, anterior temporal lobectomy (ATL) has consistently been shown to produce excellent seizure outcomes, particularly in patients with mesial temporal sclerosis (MTS). Falconer and Taylor introduced standardized anterior temporal lobectomy (ATL) for MTLE in 1968 (10), and the procedure has been frequently used for many years. This method removes 4–6 cm of the anterior temporal lobe, including the amygdala and hippocampus. Some depth electrode studies revealed that seizures usually originate from these abnormal mesial structures (11), suggesting that resection of the mesial structures alone may be sufficient for obtaining seizure control. Selective amygdalohippocampectomy, a procedure developed by Niemeyer in 1958, produces postoperative seizure outcomes that are comparable to those attained after ATL (12). Moreover, some studies have indicated that SAH has better neuropsychological outcomes than ATL (13). Other studies have suggested that better seizure outcomes were achieved in patients who underwent ATL than in those who underwent SAH (14), and that no significant differences in neuropsychological outcomes were found between the two surgical strategies (15). Seizure freedom is the single best predictor of quality of life in epilepsy, as recurrent seizures lead to significant cumulative morbidity and increased mortality (16). Overall, ATL is associated with a low risk of significant morbidity (17) and may result in improved life span (18).

Successful surgery is dependent on accurate preoperative localization, lateralization and delineation of the extent of resection of the epileptogenic zone. The preoperative evaluation involves a series of investigations including detailed clinical history, interictal EEG, long-term video EEG monitoring, high resolution MRI, PET, SPECT, and neuropsychology and neuropsychiatric assessment. The additional modalities include functional MRI and intracranial monitoring. The preoperative assessment is a step-wise process starting from the most basic, less invasive and most reliable modalities progressing to the more invasive and complex ones (20).

Although being the gold standard treatment for MTLE with HS, ATL remains markedly underutilized. The reasons behind underutilization are multifactorial. One reason is the perceived risks and the fears about open brain surgery (21). That's why new surgical modalities have been recently developed to provide less invasive alternatives for this surgically remediable disorder. Among these alternatives is gammaknife radiosurgery (GKR) that implies delivery of radioactive cobalt beams to the temporal mesial structures (amygdale, hippocampus and parahippocampal gyrus). The results of GKR were found to be comparable to ATL as regard seizure freedom especially with using high dose therapy (24 Gy) (22). The major advantage of radiosurgery in comparison with open surgery is its minimally invasive nature. Another advantage of radiosurgery is the possibility of better neuropsychological outcomes (23).

Stereotactic radiofrequency thermocoagulation and Stereotactic laser thermo-ablation are other minimally invasive surgical alternatives that can be used in management of MTLE with hippocampal scelerosis (24).

In this review, we searched the literature and summarized the available knowledge from literature on the long term efficacy and safety of gamma knife radiosurgery in comparison to temporal lobe epilepsy surgery in achieving seizure control and improving the neuropsychological outcomes in patients with mesial temporal lobe epilepsy with hippocampal sclerosis.

Anatomy:

The neuro-anatomical aspects of the temporal lobe are important in the most commonly performed surgical approaches for temporal lobe epilepsy (TLE): the anterior temporal lobectomy (ATL), the transcortical selective amygdalohippocampectomy (TATL), and the transsylvian selective amygdalohippocampectomy (TSAH). The differences between these approaches and the expected outcomes are best understood by knowing their microanatomical differences.

The two main objectives in epilepsy surgery are removal of the epileptogenic tissue and avoidance of surgical morbidity. Surgical approaches will be reviewed from the perspective of (1) avoidance of visual pathways (optic tract, lateral geniculate body, Meyer's loop, and optic radiations), (2) white matter pathways involved in the neurocognitive sequelae, (3) extent of the incision to the temporal stem and (4) extent of amygdalectomy (25).

The temporal lobe comprises three heterogeneous cortices: a six-layered neocortex (with superior, middle, inferior, transverse, temporal, and fusiform gyri), a three-layered archicortex that includes the hippocampus, the prepiriform area, the uncal semilunar gyrus, and the parahippocampus, a transitional region between the neocortex and the archicortex (26).

The temporal lobe is connected superiorly and medially to the insula by the temporal stem, anteromedially to the globus pallidus via the amygdala, and anterolaterally to the frontal base by the limen insulae (27).

The following five gyri are located on different temporal lobe surfaces: the superior (T1), middle (T2), and inferior (T3) gyri, the fusiformgyrus (T4), and the parahippocampal gyrus (T5), Figure 1. The above gyri are separated by multiple sulci, including S1, S2, S3, and S4. S1 is a deep sulcus that extends toward the temporal horn and serves as an important landmark for the identification of the temporal horn. S4 is a collateral fissure located at the edge of the lateral temporal horn wall that forms the collateral eminence. Medial to the superior surface of T1, the transverse temporal gyri, also known as Heschl's convolutions, extend to the depth of the sylvian fissure and mark the location of the primary auditory cortex. The posterior region of T1 is the planum temporale. This structure is larger on the left side in males (but not females) and is involved in the receptive language function (27).

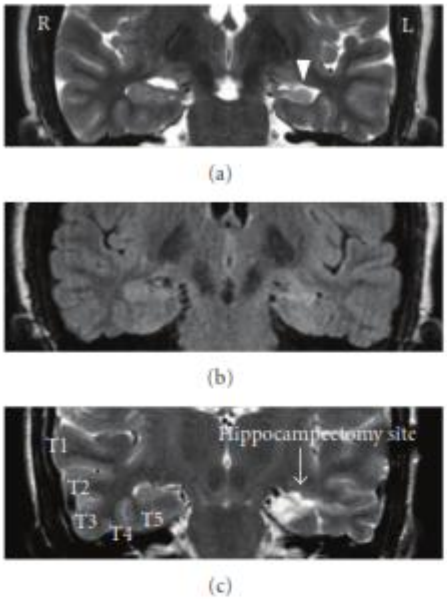

Figure 1: ((a) and (b)) Coronal T2 and FLAIR magnetic resonance image (MRI) respectively depicting a left mesial temporal sclerosis. (c) Coronal T2 MRI depicting hippocampectomy site after selective amygdalohippocampectomy on left and temporal gyri (superior (T1), middle (T2), and inferior (T3) gyri, the fusiform gyrus (T4), and the parahippocampal gyrus (T5)) on right side.

The temporal lobe has four surfaces: lateral, medial, superior, and inferior (Figure 2 (a)).

Lateral Surface:

The lateral cortical surface of the temporal lobe is located below the sylvian fissure which separates the lateral upper surface of the temporal lobe from the frontal and parietal lobes. While its anterior and inferior limits are natural bone structures, the temporal lobe is separated posteriorly from the occipital lobe by the lateral parietotemporal line, an imaginary line connecting the preoccipital notch and the parietooccipital sulcus, and it is also separated from the parietal lobe by the occipitotemporal line, a line connecting the most posterior limit of sylvian fissure with the lateral parieto-temporal line (Figure 2(a)) (26). The lateral