

## Evaluation of Temporal Lobe Epilepsy Using Proton Magnetic Resonance Spectroscopy

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### Abstract:

**Background:** Temporal lobe epilepsy (TLE) is the most common type of focal epilepsy, and often is medically refractive. For diagnosis, treatment planning, and surgical intervention, the localization of the epileptogenic focus is crucial. <sup>1</sup>H-MRS offers non-invasive metabolic data on brain tissue, and can identify biochemical changes even in normal MRI scans. The goal of the present study was to investigate the utility of Magnetic Resonance Spectroscopy (MRS) in patients with temporal lobe epilepsy.

**Materials and Methods:** A prospective observational study was performed on 60 patients with clinically and electroencephalographically proven TLE and 30 age-matched healthy controls. Both groups had a conventional MRI scan and a single-voxel proton MRS of the hippocampus. Data regarding the ratios of the metabolites N-acetyl aspartate/Creatine (NAA/Cr), N-acetyl aspartate/Choline (NAA/Cho) and Choline/Creatine (Cho/Cr) were analyzed and compared between groups. MRI and MRS data were correlated with clinical and electroencephalographic data.

**Results:** Patients with temporal lobe epilepsy showed NAA/Cr and NAA/Cho ratios which were significantly lower than those of the controls ( $P < 0.001$ ). Ipsilateral abnormalities of the hippocampus were found in 83.3% of patients and conventional MRI revealed structural abnormalities in 71.7% of patients. In MR negative cases, MRS demonstrated a superior lateralization of the epileptogenic focus than MRI and had an overall diagnostic sensitivity of 91.7%.

**Conclusion:** MRI-MRS is helpful as a complementary technique to conventional MRI in the diagnosis of TLE. MRS induced metabolic changes aid in the localization of the epileptogenic focus and assist in the diagnosis, especially when the structural MRI is normal.

**Keywords:** Temporal lobe epilepsy, Magnetic resonance spectroscopy, Hippocampal sclerosis, N-acetyl aspartate, Epilepsy imaging, Proton MRS.

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### Introduction

Epilepsy is one of the most prevalent CNS conditions globally, impacting about 50 million people and playing a key role in morbidity and diminished quality of life [1]. Temporal lobe epilepsy (TLE) is the most common type of focal epilepsy in adults and adolescents and frequently is associated with pharmacoresistant seizures that require surgical evaluation [2].

The temporal lobe has several structures that have been shown to be involved in the generation of seizures: the hippocampus, amygdala, parahippocampal gyrus, and temporal neocortex. Of these, mesial temporal sclerosis (MTS) or hippocampal sclerosis (HS) is the most common pathological substrate identified in patients with temporal lobe epilepsy (TLE) [3]. To treat epilepsy successfully and to plan surgery, the focus on which

the seizures originate must be localized and lateralized accurately.

Magnetic Resonance Imaging (MRI) is the most important imaging modality used to assess the patient with epilepsy. Structural abnormalities, including hippocampal sclerosis, cortical dysplasia, tumors, vascular malformations and gliosis, are detected by conventional MRI [4]. But an important fraction of patients with TLE may still have normal routine MRI scans in their presence of seizures.

A more sophisticated MRI tool, called Magnetic Resonance Spectroscopy (MRS), allows for the non-invasive assessment of tissue biochemistry by measuring levels of specific metabolites in the brain [5]. MRS is a type of scanning that differs from conventional MRI, which assesses structural

changes, by giving metabolic information, which can show abnormality before changes in structure.

The main metabolites measured with proton MRS are N-acetyl aspartate (NAA), choline-containing compounds (Cho), creatine (Cr), myo-inositol, and lactate. NAA is thought to be an indicator of the integrity and viability of the neurons themselves, while choline is thought to assess membrane turnover and cellular proliferation. Creatine is a relatively stable compound that is used as an internal reference metabolite [6].

Many studies have shown that epileptic hippocampi have lower NAA levels and lower NAA/ Cr and NAA/Cho ratios which are indicative of the loss of neurons and dysfunction of the hippocampus in temporal lobe epilepsy [7]. These metabolic abnormalities can be seen in the absence of conventional MRI abnormalities, enhancing the localization of seizure foci.

Proton MRS has become a more and more significant tool for pre-surgical evaluation of refractory epilepsy. Lateralization of the epileptogenic focus is important for the surgical treatment, which increases the likelihood of good outcome and limits post-operative neurological sequelae [8]. In several studies, the extent of the MRS abnormalities has been found to be strongly associated with abnormalities on electroencephalography and the presence of histological changes in the hippocampus.

The function of MRS is not limited to localization. It also gives a clue to the pathophysiology of epilepsy, and identifies dysfunction of the neurons, gliosis, and changed cellular metabolism. Variations in levels of metabolites can be linked to the frequency of seizures, duration of epilepsy, and the progression of the disease [9].

In epilepsy evaluation, both the single-voxel and multivoxel MRS techniques have been used. Multivoxel spectroscopy has the potential to provide more extensive metabolic mapping of the temporal lobes [10]; however, single-voxel spectroscopy provides higher spectral quality and is typically used to measure metabolites in the hippocampus.

Although the use of structural neuroimaging has improved, localization of the epileptogenic tissue is still difficult in MRI-negative epilepsy. Under these circumstances, metabolic imaging modalities like MRS may add useful information and aid in diagnosis with increased confidence [11].

The diagnostic yield of MRS in temporal lobe epilepsy has been variously reported to be 80% to 95% in several studies [12], most of which included patients who had conventional MRI and

electroencephalography. The results of this study indicate that MRS could play a significant role in overall evaluation of epilepsy.

The present study aimed to assess the value of proton Magnetic Resonance Spectroscopy in patients with temporal lobe epilepsy and at the same time to evaluate its usefulness in the detection and lateralisation of epileptogenic abnormalities.

**Aim:** To assess the value of MR-SPECTROSCOPY in diagnosis and localization of Temporal lobe epilepsy.

### Objectives

1. To evaluate metabolic changes in TLE patients with proton Magnetic Resonance Spectroscopy.
2. To relate the MRS findings with the conventional MRI and electroencephalography findings for localization of epileptogenic foci.

### Materials and Methods

A prospective observational study was carried out in department of Radiodiagnosis and the Department of Neurology for 2 years. A total of 60 patients with clinically diagnosed and electroencephalographically (EEG) confirmed temporal lobe epilepsy and thirty healthy age matched controls were included. Conventional MRI and proton Magnetic Resonance Spectroscopy were performed on all participants, with a 3-Tesla MRI scanner. Over both hippocampi, single-voxel spectroscopy was performed with a point-resolved spectroscopy (PRESS) sequence. NAA/Cr, the NAA/Cho and Cho/Cr ratios were calculated. Conventional MRI, metabolites ratio of MRS and seizure parameters were recorded and analyzed, along with EEG findings. The statistical analysis was done using SPSS 25. A p-value of <0.05 was considered statistically significant.

### Inclusion Criteria

- Epileptic patients with a diagnosis of temporal lobe epilepsy.
- Be between ages 10 and 60 years.
- Positive EEG findings suggestive of temporal lobe epilepsy.
- Interest in taking part in the study.

### Exclusion Criteria

- Previous epilepsy surgery.
- Intracranial tumors or acute stroke.
- Severe psychiatric illness.
- Contraindications to MRI.
- Poor-quality spectroscopy data.

### Results

**Table 1: Conventional MRI Findings in Temporal Lobe Epilepsy Patients (n=60)**

| MRI Finding           | Number (%) |
|-----------------------|------------|
| Hippocampal Sclerosis | 28 (46.7)  |
| Temporal Lobe Atrophy | 10 (16.7)  |
| Cortical Dysplasia    | 5 (8.3)    |
| Normal MRI            | 17 (28.3)  |

Hippocampal sclerosis was the most common structural abnormality. Nearly one-third of patients demonstrated normal conventional MRI findings.

**Table 2: Comparison of MRS Metabolite Ratios Between Cases and Controls**

| Metabolite Ratio | TLE Patients | Controls    | p-value |
|------------------|--------------|-------------|---------|
| NAA/Cr           | 0.92 ± 0.18  | 1.46 ± 0.21 | <0.001  |
| NAA/Cho          | 0.84 ± 0.16  | 1.35 ± 0.19 | <0.001  |
| Cho/Cr           | 1.10 ± 0.14  | 1.08 ± 0.11 | 0.42    |

Significant reductions in NAA/Cr and NAA/Cho ratios were observed among patients with temporal lobe epilepsy, indicating neuronal dysfunction.

**Table 3: Diagnostic Performance of MRI and MRS**

| Parameter           | MRI (%) | MRS (%) |
|---------------------|---------|---------|
| Sensitivity         | 71.7    | 91.7    |
| Specificity         | 90.0    | 93.3    |
| Diagnostic Accuracy | 77.8    | 92.2    |

MRS demonstrated superior sensitivity and diagnostic accuracy compared with conventional MRI for localization of epileptogenic abnormalities.

### Discussion

The present study evaluated the role of proton Magnetic Resonance Spectroscopy in temporal lobe epilepsy and demonstrated significant metabolic abnormalities among affected patients. Reduced NAA/Cr and NAA/Cho ratios were the most consistent findings, reflecting neuronal loss and dysfunction within epileptogenic temporal lobe structures.

Hippocampal sclerosis was the most common structural abnormality detected on conventional MRI. This finding is consistent with previous studies reporting hippocampal sclerosis as the principal pathological substrate in temporal lobe epilepsy [12]. However, 28.3% of patients in the present study demonstrated normal MRI findings, emphasizing the limitations of structural imaging alone.

Proton MRS revealed significant reductions in NAA/Cr and NAA/Cho ratios compared with healthy controls. Similar observations have been reported by Connelly et al., who demonstrated decreased NAA concentrations in epileptogenic hippocampi due to neuronal loss and metabolic dysfunction [13]. Reduced NAA is considered one of the most reliable metabolic markers of temporal lobe epilepsy.

The present study demonstrated a sensitivity of 91.7% for MRS, which exceeded that of

conventional MRI. This finding is comparable to previous investigations by Kuzniecky et al., who reported diagnostic sensitivities exceeding 85% for proton MRS in patients with temporal lobe epilepsy [14]. The higher sensitivity of MRS is particularly valuable in MRI-negative epilepsy.

Metabolic abnormalities detected by MRS correlated closely with electroencephalographic lateralization. This observation supports previous evidence suggesting that MRS provides functional information complementary to EEG and structural MRI [15]. In several patients with normal MRI findings, MRS successfully identified unilateral metabolic abnormalities corresponding to EEG findings.

The significant reduction in NAA/Cho ratio observed in the present study reflects both neuronal loss and relative membrane turnover within epileptogenic tissue. Previous histopathological studies have demonstrated strong associations between reduced NAA concentrations and hippocampal neuronal loss [16].

One of the major clinical applications of MRS is pre-surgical evaluation. Accurate lateralization of the epileptogenic focus improves surgical outcomes and reduces the risk of postoperative seizure recurrence. Several studies have demonstrated that patients with concordant MRI, EEG, and MRS findings experience better postoperative seizure control [17].

### Conclusion

Proton Magnetic Resonance Spectroscopy is a valuable non-invasive imaging technique for

evaluating temporal lobe epilepsy. Significant reductions in NAA/Cr and NAA/Cho ratios reflect neuronal dysfunction and provide important metabolic information beyond conventional MRI. MRS demonstrated higher sensitivity and diagnostic accuracy than structural MRI alone and was particularly useful in MRI-negative cases. The technique improves localization and lateralization of epileptogenic foci and serves as an important adjunct in pre-surgical assessment. Integration of MRS with conventional MRI and electroencephalography enhances diagnostic confidence and contributes to optimal patient management. Therefore, proton Magnetic Resonance Spectroscopy should be considered an essential component of comprehensive neuroimaging evaluation in patients with temporal lobe epilepsy.

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