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3T MRI QUANTIFICATION OF HIPPOCAMPAL VOLUME : A COMPARATIVE ANALYSIS AMONG PATIENTS WITH MESIAL TEMPORAL LOBE EPILEPSY AND CONTROL SUBJECTS

Radiology

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ABSTRACT

Aims and objective: 1) To determine the quantitative volume of hippocampus to assess the atrophy with 3T MRI in patients with mesial temporal sclerosis.
2) To compare concordance between quantitative volume against visual analysis of volume loss of hippocampus on MRI.
3) To lateralize the seizure focus in patients with temporal lobe epilepsy (TLE).
Methods: MRI studies in 25 patients with MTS and 25 control subjects were analysed by the radiologists who were blinded regarding the values of quantitative MR volume of the hippocampus. Volume analysis of the hippocampus on both sides was done on syngo.via workstation.
Result: On visual inspection of MRI images by the radiologist, 16 patients were diagnosed with right MTS, nine patients with left MTS and none with bilateral MTS. Out of 25 patients diagnosed with MTS, 20 patients were having hippocampal atrophy, while 5 patients showed increased signal intensity of hippocampus on T2WI without atrophy. On quantitative hippocampal volumetry in patients with MTS, mean volume of hippocampus on affected side was lower as compared to unaffected side - suggesting atrophy of hippocampus on the affected side. Thus, the findings were in concordance with those achieved by the radiologist on visual inspection of MRI images.
Conclusion: 3T MRI can easily detect the volume loss of hippocampus by an expertise. However, quantitative volumetric MR imaging of hippocampus can add to the diagnostic confidence and also in cases where there is subtle atrophy or when the disease is bilateral.

KEYWORDS

INTRODUCTION

Epilepsy is one of the most common neurological disorders. Although the standard medical treatment of this syndrome is based on drug administration to control seizures, 30% of patients are refractory to this treatment.

The main cause of refractory epilepsy is mesial temporal sclerosis (MTS) representing between 50% and 70% of cases and characterised pathologically by neuronal loss, atrophy and gliosis of the temporal structures.The most common surgical procedure is the resection of the anterior region of the temporal lobe and the mesial structures. As such, a presurgical evaluation of the epileptogenic focus is of vital importance in order to avoid postoperative deficits in memory and language functions.

The characteristic findings of this pathology in diagnostic imaging studies are atrophy of the hippocampus, with an increase in the intensity of the signal on T2-weighted sequences. Any structural abnormality of hippocampus can also be evaluated on MRI.

MATERIALS AND METHODS

We performed a retrospective analysis of the institutional database of patients diagnosed with refractory epilepsy between January 2019 and August 2020 in SVP hospital. Of the 45 patients found, 25 patients had MTS (15 men and 10 women, age range 18–59 years). The clinical data were obtained from the picture archiving and communication system.

The data of the control group (25 subjects: 15 men, 10 women, age range 19–59 years) was also extracted from the database using the technique of matching in order to ensure that there was no statistically significant difference regarding the age and the gender compared with the MTS group.

Acquisition protocol

Studies were conducted using a MRI scanner of 3 T .The patients were placed in the supine position with immobilisation of the head on the antenna using pads. An axial T1-weighted sequence was performed from the vertex to the posterior fossa of the brain (FOV 256mm, TE 3.37ms, TR 190 ms, flip angle 15°, slice thickness 1mm). In addition, for qualitative assessment, an acquisition of 24 slices was performed using coronal T2-weighted turbo spin echo (FOV 160mm, TE 92ms, TR 425ms, slice thickness 3.0mm) perpendicular to the hippocampus, from the genu to the splenium of the corpus callosum, 24 slices using the T2 fluid-attenuated inversion recovery (FLAIR) (FOV 230mm, TE 86ms, TR 9000ms, slice thickness 5mm) and T2 short tau inversion recovery (STIR) (FOV 180mm, TE 71ms, TR 3070ms, slice thickness 5mm), perpendicular to the temporal lobe from the anterior to the posterior horn of the lateral ventricles.

ANALYSIS

All the MRI studies in patients with MTS and control subjects were analysed by the radiologist. They were blinded regarding the values of quantitative MR volume of the hippocampus. Volume analysis of the hippocampus on both sides was done on syngo.via workstation. In MTS patients, following points were noted: (1) Normal; (2) left MTS; (3) right MTS; (4) MTS on both sides. 5) Any structural abnormality 6) MRI signal intensity of hippocampus on T2WI.

RESULTS

On visual inspection of MRI images by the radiologist, MTS was diagnosed in 55.5% (25/45) of all epilepsy patients; 16 patients were diagnosed with right MTS, nine patients with left MTS and none with bilateral MTS. Out of 25 patients diagnosed with MTS, 20 patients were having hippocampal atrophy, while 5 patients showed increased signal intensity of hippocampus on T2WI without atrophy. Among 20 patients who were diagnosed based on hippocampal atrophy, 16 patients had increased signal intensity of hippocampus on T2, while remaining 4 patients showed normal signal intensity. On quantitative hippocampal volumetry in patients with MTS, mean volume of hippocampus on affected side was 1.9 $cm^3$and on unaffected side was 3.03 cm^3- suggesting atrophy of hippocampus on the affected side. Thus, the findings were in concordance with those achieved by the radiologist on visual inspection of MRI images. In our study, no structural abnormality was found.

Table 1 – Volume of hippocampus and signal intensity of hippocampus on T2 in MTS patients

Sr. No.	Name	Age	Gender	Hippocampus volume on Right side (cm^3)	Hippocampus volume on Left side (cm^3)	Hippocampus signal intensity on T2WI	Diagnosis
1	SR	35	M	1.8	2.7	Increased on right side	Right MTS
2	AD	50	F	3	1.5	Increased on left side	Left MTS

3	VD	59	M	1.8	3.4	Increased on right side	Right MTS
4	RP	40	M	1.7	2.9	Normal on both sides	Right MTS
5	RS	23	M	3.2	1.8	Increased on left side	Left MTS
6	PS	27	F	1.4	3.5	Increased on right side	Right MTS
7	IT	36	M	3	2.8	Increased on left side	Left MTS
8	FP	48	M	1.5	3.4	Increased on right side	Right MTS
9	VM	45	F	1.8	3	Increased on right side	Right MTS
10	SP	58	M	2.7	2.9	Increased on right side	Right MTS
11	AA	50	F	2.8	1.8	Normal on both sides	Left MTS
12	AN	35	M	1.4	3.6	Increased on right side	Right MTS
13	YT	40	F	3	1.7	Increased on left side	Left MTS
14	RP	45	M	3	2.9	Increased on right side	Right MTS
15	RU	57	F	2.7	1.4	Increased on left side	Left MTS
16	HD	50	M	1.4	3	Increased on right side	Right MTS
17	SG	53	F	1.7	2.8	Normal on both sides	Right MTS
18	SS	46	M	3.4	1.8	Increased on left side	Left MTS
19	PR	57	M	3	2.8	Increased on right side	Right MTS
20	DS	37	M	1.5	2.8	Increased on right side	Right MTS
21	CB	24	F	3.2	1.8	Increased on left side	Left MTS
22	MD	29	M	1.8	3	Increased on right side	Right MTS
23	GK	35	F	2.7	2.9	Increased on left side	Left MTS
24	FG	54	F	1.8	2.8	Normal on both sides	Right MTS
25	PR	18	M	1.6	3.4	Increased on right side	Right MTS

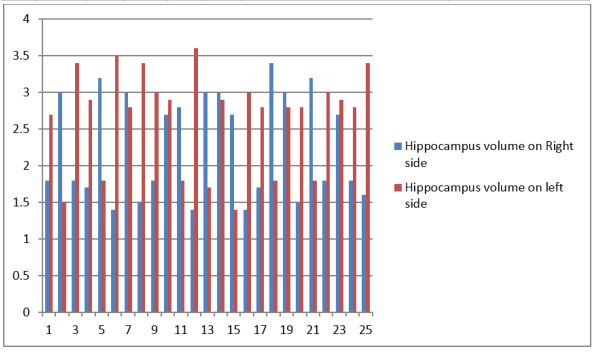


Figure I – Volume of hippocampus in patients with MTS on quantitative MR volumetry

In the control group, no significant difference between the hippocampus volume between both sides was observed. Between the control group and the group of patients diagnosed with MTS no significant differences were observed by age and gender. Mean volume of hippocampus in control group on right side was 3.09 cm3and on left side was 3.05 cm3 in our study.

Figure II- Mean volume of hippocampus in MTS patients and controls

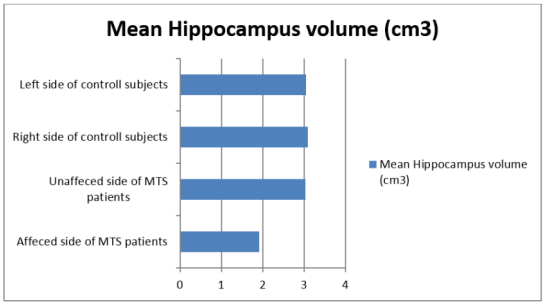


Table 2 – No. of patients diagnosed with MTS based on specific MRI findings

Study group	No. of patients diagnosed with MTS based on increased signal intensity of hippocampus on T2 without atrophy	No. of patients diagnosed with MTS based on hippocampus atrophy with or without increased T2 signal intensity of hippocampus
Right sided MTS	3	13
Left sided MTS	2	7
Bilateral MTS	None	None
Control	None	None

DISCUSSION

About fifty million people in the world have epilepsy, and the World Health Organization estimates a related morbidity of nearly 7.5 million disability-adjusted life years (health years lost) by 2015 (3).

About 30% of patients with epilepsy do not respond to adequate medical treatment (4). They are then said to have medically refractory or intractable epilepsy and the most effective treatment options for them is surgical resection of epileptogenic lesion.

Mesial temporal lobe sclerosis is the most common cause of complex partial seizures and also it is the most common structural abnormality in human epilepsy (5). MRI is the imaging modality of choice for the evaluation of patients with seizures, especially in mesial temporal lobe epilepsy. The role of MRI in the evaluation of patients with epilepsy is to identify underlying brain pathologies that relate to the patients symptoms and that helps to characterize the clinical syndrome (6).

Interpretations of MR images in mesial temporal lobe sclerosis require knowledge of the MRI anatomy and pattern of structural changes in the hippocampus. The morphological changes in mesial temporal lobe sclerosis can be grouped into primary and secondary.

The primary changes include:

- A small atrophic unilateral hippocampus
- Hyperintensity on T2 W and FLAIR images
- Loss of the hippocampal internal architecture and of normal digitations of the head
- Previous studies documented that visual MRI evaluation of hippocampal size, architecture and signal intensity changes have sensitivities of 87-100% (7-9) with the eye being able to detect asymmetry of 14% or more (9,10).

The secondary changes on the other hand include:

- Unilateral atrophy of the mamillary body, fornix columns (circuit of paper), and the amygdala.
- Increased T2 W signal in the anterior temporal lobe white matter with loss of grey-white demarcation in the ipsilateral anterior temporal lobe.
- Unilateral dilatation of the temporal horn (a less reliable secondary sign)

These secondary changes are seen in about 40-60% of patients with MTS. The secondary changes alone are unreliable, but they can be used with the primary findings to increase the diagnostic accuracy. In cases of bilateral hippocampal abnormalities, secondary findings can determine the more important side to resect. They also serve as a pointer in subtle changes and thereby improving sensitivity.

It is difficult to detect hippocampal sclerosis by CT. (11). CT can only detect approximately 30% lesions in focal epilepsies (2). CT is however, recommended in emergency situation.

Not all temporal lobe epilepsy is refractory to medication, despite the presence of MTS. Until clinical trials indicate otherwise, surgery is not indicated but life-long medical treatment is advocated. (12)

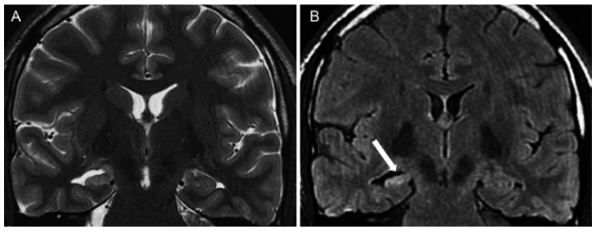
MR using simple visual analysis is the most extensively used imaging technique. It has a greater sensitivity for lesion detection in patients with intractable epilepsy. It is widely available, and trained observers readily detect MTS or other causes of epilepsy. MRI technique using visual inspection is the standard practice in our setting, hence there is need for our radiologists to master this available technique.

The normal volume of hippocampus in the Indian population is 2.411 cm^3, with the mean RHV as 2.424 cm^3 and the mean LHV as 2.398 cm^3. Using 2 SD, a lower limit of 1.813 cm^3 can be set for the HV and values below this may be considered to be abnormal. (1) In our study, values less than or equal to 1.8 were considered as atrophy of hippocampus.

In our study, there was significant difference in the volume of hippocampus in MTS patients as compared to control group and there was concordance between findings of quantitative volumetry and visual analysis of hippocampus on 3T MRI.

Moderate to severe hippocampal atrophy can be visually detected by most radiologists when a specialized epilepsy MR imaging protocol is performed However, MR imaging hippocampal volumetry can aid

expert visual inspection when volume loss is subtle and when bilateral volume loss is present, resulting in little or no asymmetry. Quantitative MR imaging can increase the detection of HA in TLE in both community and tertiary care settings.



Hippocampal sclerosis in a 41-year-old man with refractory right mesial temporal sclerosis. A) coronal T2-weighted image and B) coronal FLAIR images, both perpendicular to the long axis of the hippocampus. These images show a hyperintense signal, the loss of digitations and atrophy in the right hippocampal head (white arrow).

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