



## Volumetric Hippocampal Magnetic Resonance Imaging and Electroencephalogram of Epilepsy

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### ABSTRACT

Hippocampal volumetry is a method of measuring the volume or size of hippocampal structures in the brain, can be used as a diagnostic aid and monitoring of disease progression conditions or neurological disorders as well as response to treatment. Analyze volumetric measurement of Hippocampus MRI examination Brain 3D T2 FSE with EEG study results in cases of Epilepsy. Patient data was obtained through MRI examination of Brain 3D T2 FSE to measure volumetric hippocampus. These volumetric results are compared with EEG interpretation in cases of epilepsy. Statistical analysis was performed to identify the correlation between volumetric changes in the hippocampus and EEG results. There was no difference in the volume of the left hippocampus smaller than the right based on MRI measurements of Brain 3D T2 FSE in cases of epilepsy. Most (77.27%) shrank right and left. Left lobe temporal brain wave images in all epilepsy patients with irregular ups and downs show abnormalities based on EEG measurements. Brain wave images of the right temporal lobe in epilepsy patients are all normal. Volumetric imaging for epileptic patients cannot establish the diagnosis of epilepsy, because it cannot show a sensibility between the left and right hemispheric images

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## **INTRODUCTION**

Epilepsy is one of the most common neurological disorders characterized by prolonged seizures, epilepsy was once associated with sin, demonic possession, madness and in infectious areas, this is reflected in the difficult aspects of finding a job, following formal education, marriage and friendship (Javadi et al., 2017). Stigma in epilepsy is associated with poor quality of life, low economic quality status, in 1949 by Caveness conducted a stigma study, especially in Asian, African, European countries, to measure the magnitude of epilepsy stigma, attitudes and life (Jien et al., 2019). Indonesia, the largest archipelagic country in the world with a population of approximately 264 million people, is an ethnically diverse country with diverse cultures, it is important to understand the variability regarding the level of attitudes towards epilepsy in Indonesia (Nugraha Agung et al., 2022).

ASEAN countries do not use epilepsy surgery, due to lack of surgical personnel and epilepsy surgery centers, limited surgical evaluation due to lack of expertise of expert doctors (Thuy Le et al., 2019). In the range of 2019, according to the source "The Epidemiology of Global Epilepsy" 70 million people in the world suffer from epilepsy and almost 90% of epilepsy sufferers live in urban areas, the average prevalence of epilepsy is recorded at 1.03 in developed countries (Singh & Trevick, 2016). Indonesia is one of the developing countries where an estimated 1.1 to 1.8 million people suffer from epilepsy out of 237.6 million people in Indonesia.

The high incidence of epilepsy in developing countries affects fertility and population because of its negative impact on people with epilepsy (Nugraha Agung et al., 2022), in Indonesia, lack of infrastructure remains a major obstacle in the development of basic clinical services (Thuy Le et al., 2019).

This EEG examination is included in one of the main diagnostic tests for epilepsy. This examination also plays a role in diagnosing other brain disorders, such as brain tumors, brain dysfunction, brain inflammation (encephalitis), and sleep disorders (Fürbass, 2017). The main purpose of EEG examination is to obtain an accurate record of electrical activity in the brain, resulting in an accurate interpretation. EEG examination aims to detect whether there are abnormalities in the brain. This examination is usually done if there are indications of epilepsy, dementia, narcolepsy, nervous system abnormalities, brain or spinal abnormalities, and mental disorders. Examination of the brain with this method is carried out using small metal discs (electrodes) attached to the scalp. You need to know that brain cells communicate through electrical impulses and are active at all times, even while sleeping. This activity is then displayed as wavy lines on the EEG record. Examination to see abnormalities and abnormalities of the hippocampus and used as the Gold Standard, namely Electro Enpalography (EEG) (Fürbass, 2017).

The use of volumetrics for surgery also does not have a fixed percentage. Decision making regarding brain surgery is based on a thorough evaluation by a medical team, including neurosurgeons (National Institute of Neurological Disorders and Stroke, n.d.). Hippocampal volumetrics can provide important

information about the size and condition of the hippocampus that can help in the planning and execution of brain surgery (Sone et al., 2016)

There are 2 methods in measuring the hippocampus using MRI and EEG. What are the advantages and disadvantages of each method between volumetric Hippocampal MRI examination Brain 3D T2 FSE with gold standard EEG study results in Epilepsy cases.

## LITERATURE REVIEW

The hippocampus is a structure located in the medial temporal lobe, about 5 cm in size, which resembles a seahorse (hippocampus) and has a large cashew-like shape under the neocortex (Medina et al., 2013). The hippocampus plays a role in regulating cognitive functions such as memory, emotions, motivation, fear, habits, anxiety, and stress (Bartsch & Wulff, 2015). The volume size of the left hippocampus is (0.43 cm<sup>3</sup>) and the right is (0.42 cm<sup>3</sup>) male and female no difference, measured in one side of the coronal piece (McHugh et al., 2007). The hippocampus is an important part of the central nervous system that plays a role in memory and learning (Butler et al., 2013). The volume size of the left hippocampus is (0.43 cm<sup>3</sup>) and the right is (0.43 cm<sup>3</sup>) male and female, there is no significant difference in women (McHugh et al., 2007).

Hippocampal volumetric measurement is a measurement performed using an MRI device using a semi-automatic system performed by identifying and drawing the contour of the Hippocampus on each slice of brain images taken through MRI scans. Volumetric is then calculated by multiplying the contour area by the thickness of each slice resulting in the value of the Hippocampal volume in cubic centimeters (cm<sup>3</sup>), and the structure of the Hippocampus. Volumetric hippocampus in patients with atrophy may vary depending on the severity and type of atrophy that occurs, as well as other individual factors (McHugh et al., 2007). In Alzheimer's disease, there is a volumetric decrease in the hippocampus. A volumetric hippocampal size of 0.213 cm<sup>3</sup> was also associated with the progression of Alzheimer's disease epilepsy at the youngest age of 40 years (Peixoto-Santos et al., 2018). The average volumetric total hippocampus decreased by 32.70%, with no significant difference between the size of the left and right hippocampus (Duan et al., 2020).

The 3D T2 FSE (fast spin echo) sequencing technique is an imaging method used to obtain three-dimensional MRI images of the Head using the fast spin echo technique, focusing on T2 weighting. The data produced through this technique is in the form of measuring the volume of the hippocampus on the left and right sides of the brain. This measurement can be done using three-dimensional imaging techniques on MRI (Coan & Cendes, 2013). The way the hippocampal volumetric works is done through brain scanning techniques such as MRI (Magnetic Resonance Imaging). MRI produces three-dimensional images of the brain that make it possible to measure the size of the hippocampus accurately. Volumetric hippocampus can be used in a variety of medical contexts. Diagnostics and research are its two main applications. In the case of epilepsy, hippocampal volumetrics can assist doctors in evaluating and diagnosing the condition (Jermakowicz et al., 2017).

EEG electroencephalogram is an examination used to detect diseases and disorders of the brain and nerves. EEG recording uses a gold standard method known as the 10-20 International System. This recording, also known as full montage EEG (fm-EEG), is used to diagnose epilepsy and status epilepticus. However, the lack of systematic studies on the diagnostic usefulness of reduced montage (rm-EEG) became an obstacle in adopting this method (dr. Andi Munawar., 2023). An EEG examiner is measured by attaching electrodes connected to the patient's scalp. These electrodes record electrical signals generated by neural activity within the brain, and these signals are recorded in waveform by an EEG device with 10 electrodes, producing frequency values/brain waves. The reduced montage rm-EEG sensitivity is lower in detecting single epileptiform spikes compared to other epileptic disorders. However, this does not necessarily mean lower sensitivity in detecting major abnormalities. The usefulness of rm-EEG in detecting pathological patterns other than electrographic seizures, which can help identify patients with a higher risk of seizures, has not been thoroughly studied (Westover et al., 2020).



Figure 1. EEG of Normal Epilepsy

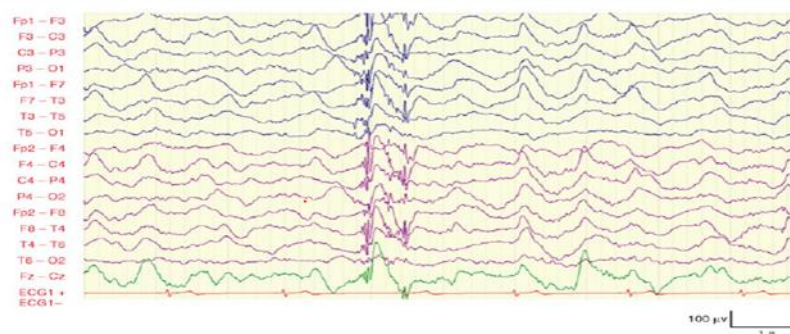


Figure 2. Abnormal Epilepsy Eeg Results

### How to Measure the Hippocampus with MRI

To get a 3D-IR FSPGR Coronal image, a thin slice of 3 mm is taken perpendicular to the hippocampus. This slice is used to measure the size of the hippocampus, starting from the posterior part of the cerebellum to the anterior border of the Genu Corpus Callosum. To get an idea of the desired slice reformat, it is necessary to obtain an isotropic data set (Elmaoğlu & Çelik, 2012)

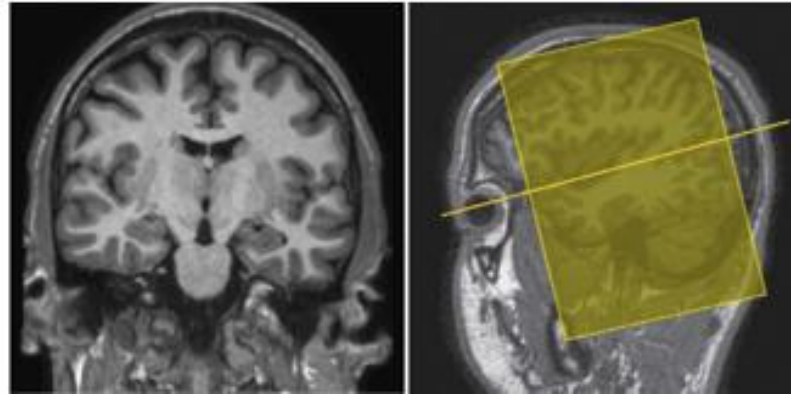


Figure 3. GRE Weighted T1obtained Through Hypokampu as Part of 3D Acquisition (Elmaoğlu & Çelik, 2012)

Acquisition of a 1.5 MRI scanner with a 32-channel head coil to take Hippocampal MRI images obtained in 3D. Shooting is carried out using a gradient-echo echoplanar imaging sequence automatically will appear cut, coronal, axial, sagittal images, with parameters of repeat time (TR) of 2,897 ms, echo time (TE) at 50 ms, a return angle of  $90^\circ$ , and a field of view (FoV) of (1.92 mm<sup>2</sup>). Each volume produces 34 oblique axial slices almost perpendicular to the hippocampus, with a matrix measuring (64 × 64 × 34) and a slice thickness of 3 mm. The size of the resulting voxel is (3 × 3 × 3 mm) (Javadi et al., 2017).

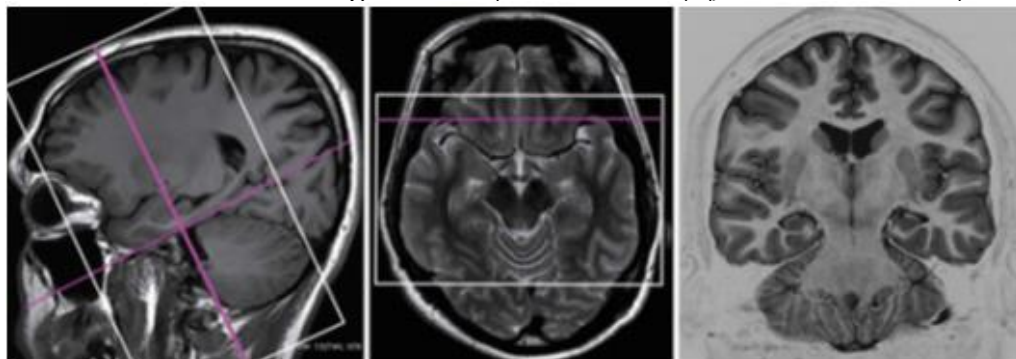


Figure 4. Oblique Coronal Featuring Temporal Lobe (Elmaoğlu & Çelik, 2012)

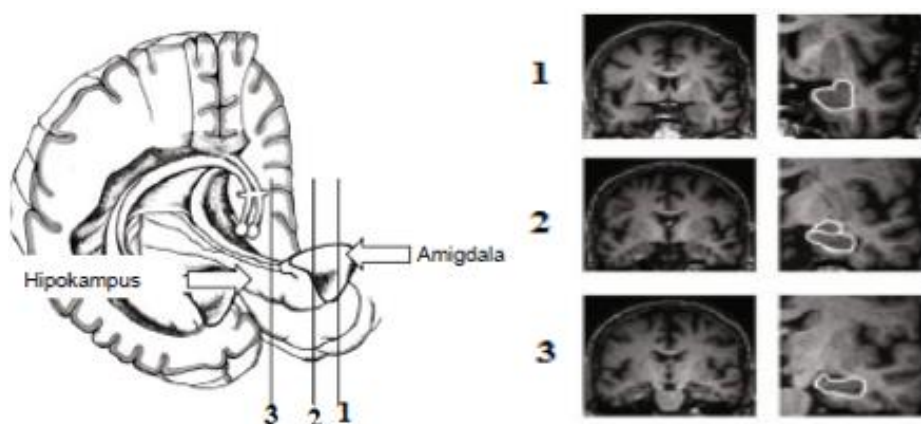


Figure 5. Shows Three Different Proportions Passage Through the Hippocampus, Terdiri Dari (1) Amigdala,(2)Amigdala/Hipokampus,(3)Hipokampus (Zach Et Al., 2020)

To measure the increase in amplitude using electrodes on the scalp, several areas of the cortex measuring several square centimeters must be activated simultaneously (Fürbass, 2017). The results of the electroencephalogram (EEG) are considered normal under conditions of symmetry in the pattern and amplitude of waves between the two hemispheres of the brain, The wave pattern follows a regular rhythm and corresponds to the expected speed, The absence of sharp waves with normal development and The absence of slowed or abnormal wave activity (dr. Andi Munawar., 2023).

The following framework of this research concept can be illustrated with the following scheme:

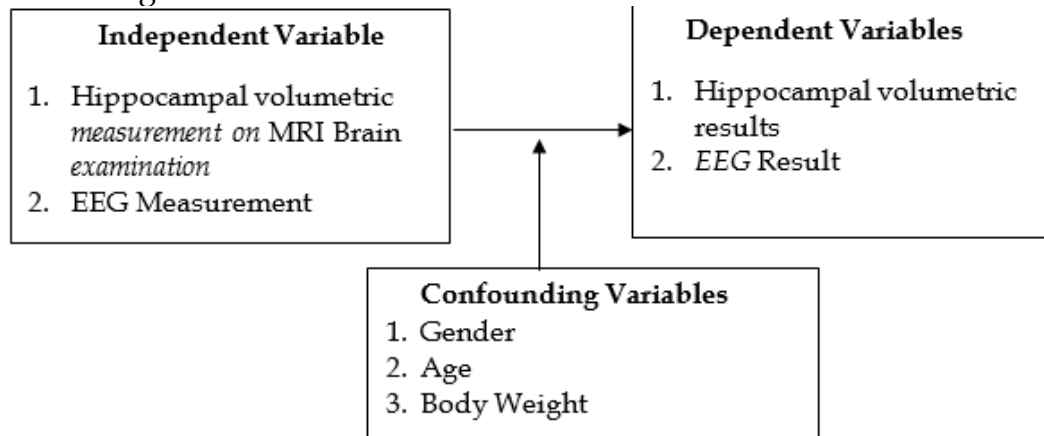


Figure 6. Conceptual Framework

## METHODOLOGY

The type of research in this study is quantitative with experimental methods, namely researchers observe the results of hippocampal volumetric examination and EEG examination. The study population also underwent MRI Brain Epilepsy examination at the hospital. Bhayangkara Tk. 1 Puskor with the criteria of patients aged 15-50 years, indications of suffering from epilepsy. And exclusion criteria with a sample of research samples used 22 patients.

## RESULTS

Data collection will be carried out in the period June - September 2023 at the Hospital Installation Radiology. Bhayangkara Tk.I Puskor Polri in Jakarta. The characteristics of the Research Sample can be shown in table 1.

Table 1. Data Characteristics

Characteristic	Sum	Percentage ( % )
<b>Gender</b>		
Legal Law	10	45,45
Woman	12	54,54
<b>Age</b>		
15-30 years	9	40,90
31-40 years	6	27,27
41-50 years	7	31,81
<b>Weight</b>		
26 - 35	13	59,09
46 - 55	4	18,18
56 - 65	5	22,72



The data showed an almost balanced proportion of male and female sexes in the study sample, reflecting the representative inclusion of these two groups. Most of the study subjects were in the age group of 15-30 years and 41-50 years, with a smaller proportion being in the age group of 31-40 years. There was weight variation in the sample, with most subjects weighing in the 26-35 kg range, and some subjects weighing in the 46-55 kg and 56-65 kg ranges.

These population characteristics reflect variations relevant to research on epilepsy. The implementation of the Hippocampal volumetric technique and comparison with EEG results in this population can provide a deeper understanding of the relationship between hippocampal structure and manifestations of epilepsy. The study's findings will hopefully provide a stronger guide for the diagnosis and management of Epilepsy cases, as well as a contribution in the development of more effective therapies for patients with this condition. Volumetric measurement of hippocampus MRI examination of brain 3D T2 FSE study in cases of epilepsy.

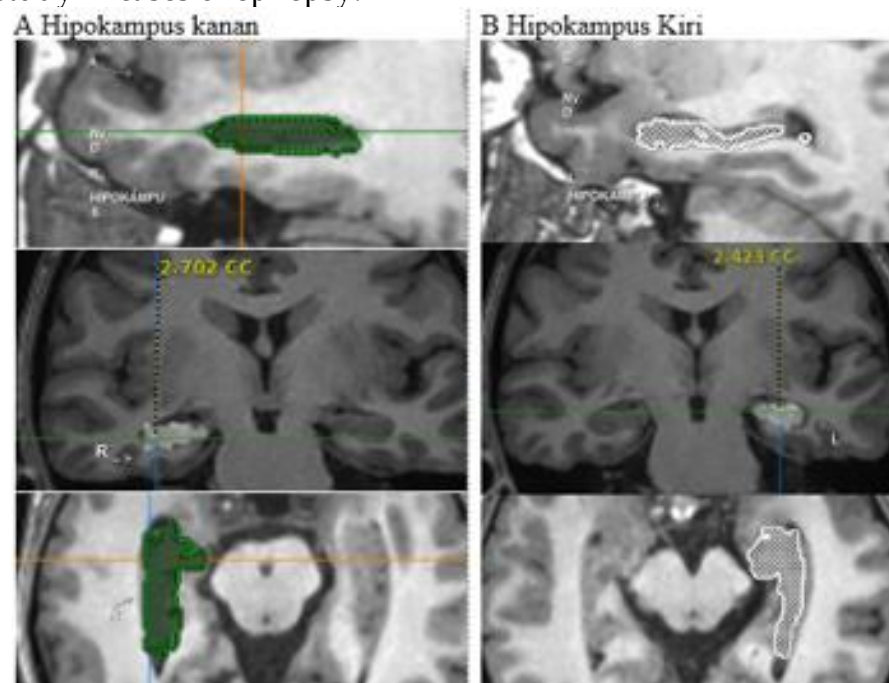


Figure 7. Hippocampal Volumetric Results

Figure 7 above shows a 3D MRI image. (a) Showing no obvious structural changes a and b are volumetric images that show no significant difference. volumetric right hippocampus, each of which is calculated using measurements of the hippocampal area Semi-automatic linear measurement method system on green sagittal, coronal, axial brain scanning with volumetric results of 2.702cm<sup>3</sup> compared to figure B The left hippocampus which is white with a volumetric of 2.42cm<sup>3</sup> is scanning sagittal, coronal, axial, each measured from fibria The upper hippocampus is surrounded by the nucleus of the amygdala to the tail alveus Lateral hippocampus and evasion using semiautomatic linear mearsurement method system on 3D MRI 1.5T there was no significant increase in volumetric or anatomical structure.

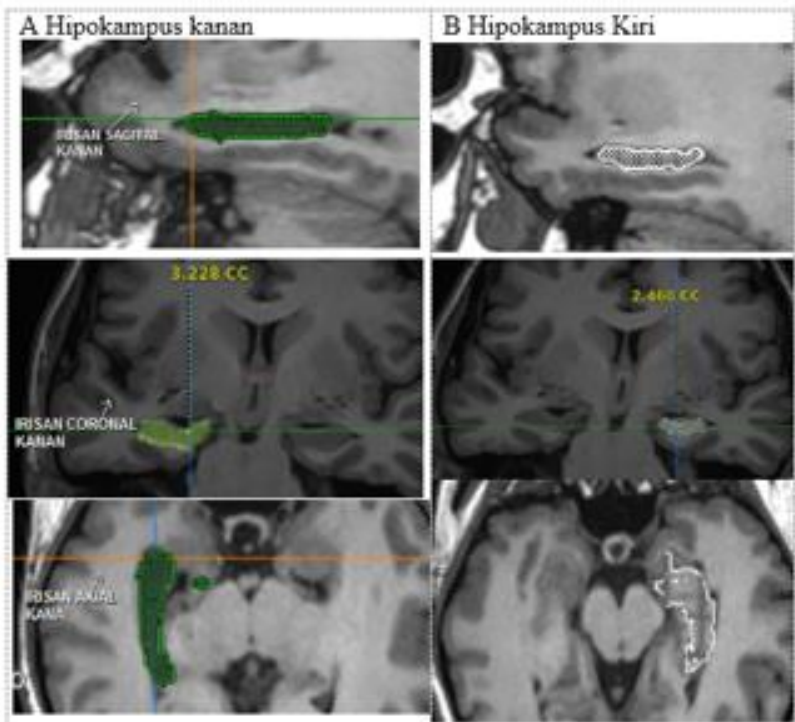


Figure 8. Hippocampal Volumetric Results

Figure 2 3D MRI image (a) is a picture of the right Hippocampal MRI volumetric showing an increase in the volumetric Hippocampus as well as structural changes marked with the number 3,228 cc. Provides a structural picture of the brain. In this study, volumetric measurement data of the hippocampus showed a decrease in the size and volumetric structure of both the right and left hippocampus marked with numbers and volumetric values. In the table, has analyzed the volumetric right and left hippocampus in a number of subjects with various characteristics such as age, sex, and weight. In the data that have been presented, it is seen that the volumetrics of the right and left hippocampus vary significantly between the subjects. Shows the importance of considering factors such as age.

Table 2. Volumetric Sample Distribution

Hipokampus	Sum	Presentase (%)
<b>Right</b>		
Small size	7	31,8
Large size	15	68,1
<b>Left</b>		
Small size	9	40,9
Large size	13	59,0
Total	44	100

Based on the results in table 3 above, information on the results of hippocampal volumetric measurements was obtained, the majority of samples were epilepsy with a total of 44 images (100%) while the small samples on the left amounted to 9 images (40.9%).



Table 3. EEG Table Data from Doctor Reading Results

Hipokampus	Klinis	Sum	Hasil EEG Epilepsy	Percentage (%)
Right	normal	22	-	100
Left	Epilepsy Dirt	22	22	100

Abnormal EEG results on the left side of the brain indicate abnormal or irregular electrical activity in the left side of the brain. This could be an indication of an epileptic disorder affecting the left brain area. Abnormalities on the EEG can include excessive brainwave activity or epileptic seizures detected in the EEG recording. Left hippocampal volume as measured through MRI reflects the physical size of the hippocampal portion on the left side of the brain. This volume data can be used to understand whether there are any structural changes in the left hippocampus that may be related to epileptic activity detected in the EEG. In the data provided, there was a visible variation in the volume of the left hippocampus among subjects. Some subjects had a smaller left hippocampal volume than others. In the context of epilepsy research, abnormal EEG results on the left side of the brain can show epileptic foci located around the left hippocampus. Variations in left hippocampal volume between subjects may indicate the presence of structural changes associated with epilepsy. The hypothesis is that in some subjects, the left hippocampal volume may undergo atrophy or other structural changes as a result of chronic epileptic activity.

Table 4. Results of Volumetric Analysis of Hippocampus of Epileptic Patients

Hippocampus Area	Mean	Median	Standard deviation	Value min-maks	Normality test
Right hippocampus	2,2845	2,1840	0,53173	1,51 - 3,23	0,248
Left hippocampus	2,2476	2,2285	0,47980	1,62 - 3,09	0,089

The results of Hippocampal volumetric descriptive statistical analysis in Epilepsy patients based on table 4.3 were obtained as follows:

1. The average volume of the epilepsy patient's right hippocampus is 2.2845 cc, the middle value is 2.1840 cc, the standard deviation is 0.53173 cc, the minimum value is 1.51 cc, the maximum value is 3.23 cc, the normality test is a significant value  $p = 0.248$  ( $p > 0.05$ ), indicating that the data is normally distributed.
2. The left hippocampus of epilepsy patients averaged 2.247 cc volume, middle value 2.2285 cc, standard deviation 0.47980 cc, minimum value 1.62 cc, maximum value 3.09 cc, normality test significant value  $p = 0.208$  ( $p > 0.05$ ), indicating normal distributed data.

Statistical analysis of the difference in the volumetric value of the right and left hippocampus based on an independent test T-Test obtained the result of  $p = 0.810$  ( $p > 0.05$ ), then the conclusion is that there is no difference in the volumetric value of the right and left hippocampus in patients with epilepsy.

Table 5. Results Descriptive Analysis of Patient Characteristics

Karakteristik Pasien	Mean	Median	Standard deviation	Value min-maks	Normality test
Age	33.95 years	33 years old	9.93 years	20,00- 50,00	0,025
Weight	41,60 kg	32 kg	14,91 kg	26,00 - 77,00	0,001

Results Descriptive statistical analysis of patient characteristics based on table 4.4 is obtained as follows:

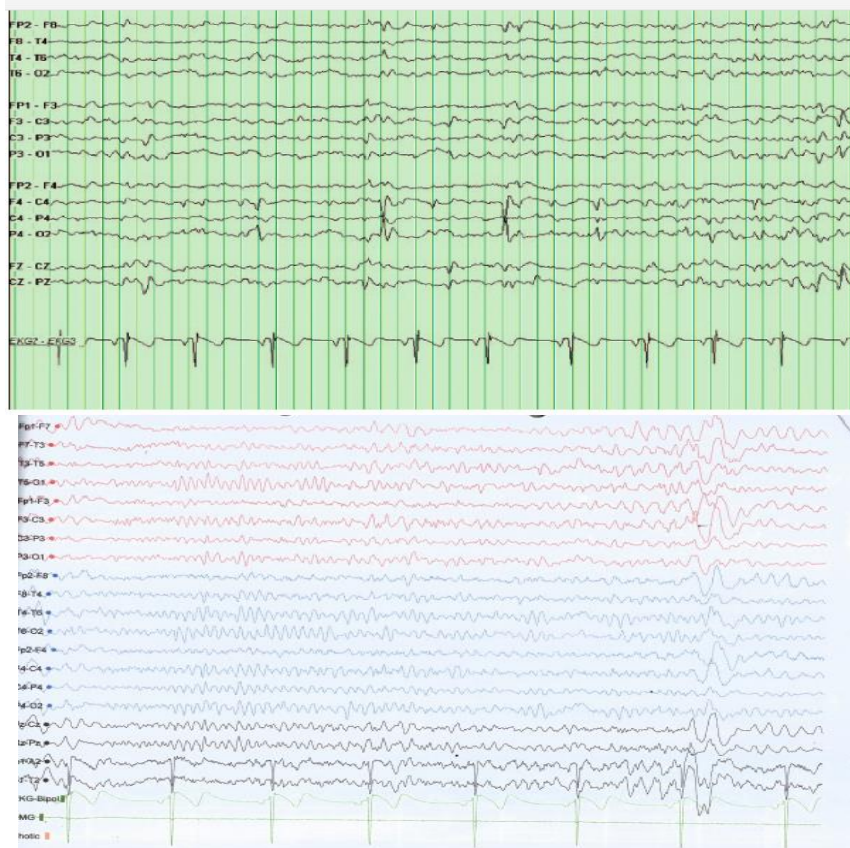
1. Patient age mean 33.95 years, middle value 33 years, standard deviation 9.93 years, minimum value 20 years, maximum value 50 years, normality test significant value  $0.025 < 0.05$  data not normally distributed.
2. The patient's average body weight was 41.60 kg, middle value 32 kg, standard deviation 14.91 kg, minimum value 26 kg, maximum value 77 kg, normality test significant value  $0.001 < 0.05$  data was not normally distributed.

Table 6. Results of Descriptive Analysis of Gender Characteristics

Jenis Kelamin	Frekuensi	Persen
Perempuan	12	54,5
Laki - Laki	10	45,5

Gender characteristics of patients based on the table obtained results: 12 female patients (54.5%) and 10 male patients (45.5%).

## Wave picture of EEG examination results in epilepsy cases



### Figure 9. EEG Wave Results

EEG results often indicate the presence of typical epileptic waves. These epileptic waves can be spikes and waves that are abnormal in brain activity patterns. Epileptic activity usually occurs repeatedly and suddenly. Recording is carried out in a conscious state (awake and sleep). The background is a 9-11Hz alpha wave of medium amplitude that responds to open and close eyes. There are high amplitude spike / sharp waves in the left temporal that appear periodically. In photic activation there is no visible driving response.

Abnormal EEG indicates potential epileptogenicity in the left temporal region. Advantages and disadvantages of each method between hippocampal volumetric MRI examination of brain 3D T2 FSE with EEG results Study in epilepsy cases

## DISCUSSION

### **Volumetric Measurement of Hippocampus MRI Examination of Brain 3D T2 FSE Study on Epilepsy Case**

In this study, the results of volumetric measurements of the right hippocampus of 22 patients with epilepsy cases showed an average value of 2.2845 cc. While the left hippocampal volumetric measurement of 22 patients showed an average value of 2.2476 cc. In evaluating the presence of atrophy, it is important to know the normal volume range of the hippocampus. In this study, using imaging methods using 400 oblique incisions of T1 and three-dimensional MRI on normal subjects, it was found that the average volume of the right and left hippocampus was 2.90 cm<sup>3</sup> and 2.78 cm<sup>3</sup> measured through three coronal, sagittal, axial pieces, which showed a marked difference between the two sides. The volume of the hippocampus is in the middle of the hippocampus volume range, which is between 1.73 cm<sup>3</sup> to 5.68 cm<sup>3</sup> (Nobis et al., 2019), (Honeycutt & Smith, 1995).

The average volumetric total hippocampus decreased by 32.70%, without any significant difference between the size of the left and right hippocampus (Duan et al., 2020). The decrease in right hippocampal volume in this study showed a decrease of 21.38% (from normal volume of 2.90 cc to 2.285 cc). Left hippocampal decrease of 19.06% (from normal volume of 2.78 cc to 2.25 cc) While in general the decrease in hippocampal volume averaged 32.70%. A decrease of 21.38% in hippocampal volume was confirmed by EEG results showing abnormal EEG diagnosis (indicating potential epileptogenicity or epilepsy). Of the patients, 22 people were all diagnosed with epilepsy.

The results of research at the National Police Hospital showed that the volumetric decrease in the right and left hippocampus was not as severe as in the case studied by Bremner. Volumetric measurement involves calculating the volume or three-dimensional size of these brain structures using data obtained from MRI examinations.

In this context, MRI examination performed on T2 FSE otak. 3D refers to a type of MRI scan called "Turbo Spin Echo" with a three-dimensional mode This study aimed to evaluate volumetric changes in the hippocampus in epilepsy patients in an effort to understand how this condition can affect brain structure. Volumetric measurement of the hippocampus through 3D T2 FSE MRI

examination can provide valuable information about structural changes associated with epilepsy. Changes in the size of the hippocampus may indicate damage or structural changes associated with recurrent epileptic seizures. This kind of research can provide further insight into factors that may contribute to epilepsy and lead to the development of better treatment strategies. The volumetric size of the hippocampus that shrinks right 1,795 cc and left 1,618 cc, from the normal size of 2.90 cc and 2.78 cc, has epilepsy. but not all sizes that shrink epilepsy. The volumetric size of the hippocampus of 2,779 cc and 2,771 cc experiencing epilepsy, means that there is no difference in the volumetric value of the right and left hippocampus in people with epilepsy.

#### **Wave Picture of EEG Examination Results in Epilepsy Cases**

In cases of epilepsy, EEG examination is often used to assist in the diagnosis of patients. The brain waves observed in the EEG examination can provide clues about the presence of epileptiform activity (waves indicating epileptic seizures) in the patient's brain activity.

To identify typical wave patterns associated with epileptic seizures. This could include observation of blunt or sharp waves that may appear during a seizure period, or changes in wave patterns before, during, and after a seizure. Information from the EEG examination can assist the doctor in planning appropriate treatment and monitoring the patient's response to treatment.

Electroencephalogram (EEG) results are considered abnormal under conditions such as: There is no symmetry in the pattern and amplitude of waves in the same regions on both sides of the brain. Irregular wave patterns, with wave speeds that are slower than they should be. The appearance of waves that are usually not visible, such as sharp waves, spikes, spikes, spikes, and waves with slower speeds. However, about 10-40% of Epileptic patients do not show abnormal EEG patterns, whereas abnormal or mild EEG patterns that are not typical can be found in 15% of the population whose development is normal. The analysis process may involve the identification of waves such as alpha, beta, teta, and delta waves, as well as the detection of typical epileptiform wave patterns. This study contributes to further understanding of the relationship between brainwave activity in EEG examination and Epileptic seizures. This can help improve the treatment and treatment of epilepsy patients by providing further guidance to doctors in interpreting EEG test results.

Advantages of hippocampal volumetrics:

1. The 3D T2 FSE MRI method allows better visualization of anatomical structures, including the hippocampus, and can identify changes in size or shape that may be associated with cases of epilepsy.
2. Accurate Volumetric Measurement: The volumetric method can measure accurate Hippocampal volumetrics. In Epilepsy case studies, changes in hippocampal volume can be an important indicator in identifying the cause and progression of epilepsy.
3. Non-invasive: MRI is a non-invasive method, which means no surgery or body penetration is required. Making it more accessible and safer for patients.

#### Volumetric deficiency of the hippocampus:

1. Depending on the Equipment: The quality of the resulting image is highly dependent on the quality of the MRI equipment and the scanning techniques used. Deficiencies in scanning equipment or techniques can result in unclear images and may affect the accuracy of volumetric measurements.
2. Cost and Access Limitations: MRI examinations can be expensive and are not always widely available in all locations. This can hinder patient access to this method, especially in areas with limited resources.

#### Advantages of EEG Study results:

1. Electrical Activity Detection: EEG (Electroencephalogram) is a very sensitive method to detect electrical activity in the brain and show nerve function in cases of epilepsy. To identify abnormal brain wave patterns that could be associated with cases of Epilepsy.
2. Real-time Monitoring: EEG allows monitoring brain activity in real time. This is useful for recording rapid changes and gaining a deeper understanding of ongoing epileptic activity.

#### Disadvantages of EEG Study results:

1. Limitations of Spatial Resolution: One of the major disadvantages of EEG is the limitation in spatial resolution. This means that it provides information about overall brain activity, but is not capable of providing detailed anatomical images like imaging methods such as MRI can.
2. Limitations in Specific Location Identification: An EEG may be able to identify epileptic activity, but it is difficult to accurately identify the specific location within the brain where this activity occurs. So it can limit the ability to determine the source of epilepsy with high accuracy.

## CONCLUSIONS AND RECOMMENDATIONS

The conclusion of this study is that there is no difference in the volume of the left hippocampus smaller than the right based on MRI measurements of Brain 3D T2 FSE in cases of epilepsy. Most (77.27%) shrank right and left. Left lobe temporal brain wave images in all epilepsy patients with irregular ups and downs show abnormalities based on EEG measurements. Brain wave images of the right temporal lobe in epilepsy patients are all normal. The determination of volumetric images for epileptic patients cannot establish the diagnosis of epilepsy because it cannot show the sensibility between the left and right hemisper images. The advantage of volumetric measurement of the hippocampus in people with epilepsy is that it allows better visualization of anatomical structures, including the hippocampus, and can identify changes in size or shape that may be associated with cases of epilepsy and can be compared to EEG waves. For the determination of the dosage of treatment.

## FURTHER STUDY

The study's sample size was limited to 22 patients, which allowed for the continuation of further research with a larger research sample and a focus on specific epilepsy.



## **ACKNOWLEDGMENT**

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