Magnetic Resonance Imaging of the Brain in Epileptic Adult Patients: Experience in Ramathibodi Hospital

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Objective: *The purpose of the present study was to classify the imaging structural abnormalities of epileptic adult patients referred for magnetic resonance imaging (MR imaging) of the brain at Ramathibodi Hospital and to correlate with the clinical data and EEG.*
Material and Method: *MR imaging of 91 adult epileptic patients (age ranging from 15-85 years old with an average of 36.90 years old) were retrospectively reviewed and classified into eight groups according to etiologies. Then clinical data and EEG correlations were analyzed using the Kappa analysis. All of the MR imaging of the brain were performed at Ramathibodi Hospital from January 2001 to December 2002.*
Results: *Secondary generalized tonic clonic seizure was the most common clinical presenting seizure type. Extra temporal lobe epilepsy was the most common clinical diagnosis. Of the thirty-three patients who underwent EEG before performing MR imaging, 17 had normal EEG. From MR imaging, temporal lobe lesion was the main affected location and mesial temporal sclerosis (MTS) was the most common cause of the epilepsy in patients. For age group classification, young adult (15-34 years old) and adult (35-64 years old) age groups, MTS was the most common etiology of epilepsy with cortical dysplasia being the second most common cause for the first group and vascular disease for the latter group. For the older age group (> 64 years old), vascular disease and idiopathic cause were equally common etiologies. MRI, EEG findings, and clinical data were all concordant with statistical significance.*
Conclusion: *MRI is the non-invasive modality of choice for evaluation of the epileptic patients. The result is concordant with the clinical and EEG findings. It can detect and localize the structural abnormality accurately and is useful in the treatment planning.*

Keywords: *Magnetic resonance imaging, MRI, Epilepsy, Seizure, Adult patient*

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Seizure disorder and epilepsy are paroxysmal events due to abnormal, excessive, hypersynchronous discharges from an aggregate of the central nervous system (CNS) neurons, and are a result of the imbalance of excitation and inhibition within the CNS. This abnormal activity can have various manifestations depending on the distribution of the discharge or structural abnormality[1].

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The incidence and prevalence of seizure are approximately 5 to 10% of the population or 30 to 50 cases per 100,000 person-years in the USA[1,2]. For the Southeast Asian countries, the cumulative incidence of epilepsy for Singapore children by age 9 years is 3.50 per 1,000[3]. In Thailand, one study shows that the prevalence of epilepsy in the rural population is estimated at 7.2 per 1,000 populations[4].

Complex partial seizures are the most common (55%) seizure type in adults[5]. The evaluation and management of patients with seizure are essential for

the patient's quality of life. Although about 70% of all cases have unknown causes, the specific cause is mandatory for proper patient management[2]. In several studies, head injury and brain tumor are common causes for adult patients, whereas cardiovascular disease is more common in elderly patients[2,6].

At present, there are many investigations and modalities available for diagnosis and searching the cause of the seizure, such as electro-encephalography (EEG), computed tomography (CT), magnetic resonance imaging (MRI), single-photon emission computed tomography (SPECT), as well as positron emission tomography (PET)[1,7].

MRI is a non-invasive modality for evaluation of the underlying structural brain lesion and correlation with the epileptogenic foci suspected on the basis of seizure semiology and EEG data. MRI may identify an underlying developmental abnormality, sequel of a remote insult (e.g. closed head injury) or an active process such as inflammation, infection, and tumor. MRI also has advantages of strong soft tissue contrast and multiplanar capabilities[7,8].

The purpose of the present study was to review series of epileptic adult patients referred for MR imaging of the brain at Ramathibodi Hospital to detect structural abnormalities and to describe and analyze the MRI findings in correlation with the clinical data (history and physical examination) and EEG.

Material and Method

The MR imaging and reports of all adult patients 15 years of age and older, who presented with epilepsy or seizure and underwent MRI study at Ramathibodi Hospital from January 2001 to December 2002, were searched from the databases at the Department of Radiology. Ninety-one MRI studies of 91 patients (54 females and 37 males) with age ranging from 15 years old to 85 years old (mean age: 36.90 years) were included in the present study. The patient data are shown in Table 1.

All of the studies were retrospectively reviewed by a board certified neuroradiologist or radiologist countersigned by a board certified neuroradiologist and correlated with the clinical data and EEG. The clinical data and EEG were reviewed and classified by a board certified neurologist.

The inclusion criterion was an adult patient who presented with epilepsy or seizure and had an MRI study at Ramathibodi Hospital from January 2001 to December 2002. The exclusion criterion was a patient with incomplete MRI study and clinical data.

For MRI study, all cases were studied using a 1.5 Tesla superconductive magnet (Signa and NVi/CVi, General Electric Medical Systems, Milwaukee, USA) with gradient strength of 10 and 40 mT/sec, respectively. The study protocols are shown in Table 2.

All data were analyzed and presented with number and percent in the form of tables and figures for defining the relationship of each data (MRI findings, clinical data and EEG) using the Kappa analytic method for percentage of agreement, with $p < 0.05$ was considered significance. The outcomes were defined as concordance or discordance of the clinical data, EEG, and MRI findings.

Table 1. Patients data with gender and age distribution

Age group (yr) vs Sex	Female	Male	Total
15-34 years	23	19	42 (46.15%)
35-64 years	26	15	41 (45.05%)
Over 64 years	5	3	8 (8.79%)
Total	54 (59.34%)	37 (40.66%)	91 (100.00%)

Table 2. MRI protocols for epilepsy

Sagittal SE T1W (TR/TE/NEX = 460/14/2)
Axial SE T1W (TR/TE/NEX = 400/14/2), FSE T2W (TR/TE/NEX = 4000/85/3) and FLAIR (TR/TE/NEX = 9000/120/1)
Diffusion image (B value = 1000, 3000)
Coronal GRE T2W (TR/TE/NEX = 700/20/2) of the whole brain (5/1.5 mm)
Thin slice obliqued coronal (3 mm/interleave) perpendicular to the hippocampal plane in FLAIR (TR/TE/NEX = 9000/120/2), FSE T2W (TR/TE/NEX = 3000/85/4) and 3D SPGR (TR/TE/NEX = 30/4.2/1) sequences of the whole brain
If Gadolinium administration; axial and coronal SE T1W (TR/TE/NEX = 400/14/2)

Results

From the clinical data, two major groups were classified as generalized and partial seizures. After that, various subtypes were classified as shown in Table 3. Twenty-five patients had the symptoms classified in more than one seizure type. The most common seizure type was secondary generalized tonic clonic seizure (39.17%), followed by complex partial seizure (27.50%).

Eighteen patients (19.78%) had precipitating causes, six patients (33.33%) had a previous history of childhood febrile convulsion and four (22.22%) had CNS infection. The details are shown in Table 4.

All patients were diagnosed and classified into various groups, i.e., extra temporal lobe epilepsy (n = 34, 37.36%), focal seizure (unclassified lobe) (n = 32, 35.16%), temporal lobe epilepsy (n = 11, 12.09%), and other groups (n=14, 15.38%). The patients were stratified into three age groups- young adult group (15-34 years old), adult group (35-64 years old) and old age group (over 64 years old). Each age group was classified according to the cerebral structural lobes as shown in Table 5.

From the MRI data, temporal lobe lesion was the most common abnormality detected and it was found in 60 lesions (45.45%) from 132 lesions. Mesial temporal sclerosis was the most common cause of epilepsy found in the young adult and adult age groups. Frontal lobe lesion was the second most common lesion, with 27 lesions (20.45%). Parietal lobe lesion was the third most common lesion, with 18 lesions (13.64%). The rest of the lesions were distributed in less number as shown in Table 6.

In general, structural MRI abnormalities were classified into disease categories (Table 7). In the present study, disease categories were classified according to age groups (Table 8). None of the patients was classified in a degenerative group. Regarding

Table 3. Seizure types classified by clinical data

Seizure types	No.	Percent
Generalized seizure	50	41.67
Secondary GTCS	47	39.17
Generalized clonic seizure	1	0.83
Nocturnal tonic seizure	1	0.83
Atonic seizure	1	0.83
Partial seizure	70	58.33
Complex partial seizure (CPS)	33	27.50
Simple partial seizure (SPS)	30	25.00
Convulsive syncope	4	3.33
Versive seizure	1	0.83
Myoclonic seizure	1	0.83
Tonic seizure	1	0.83
Total	120	100.00

Table 4. Precipitating causes

Precipitating causes	No.	Percent
History of childhood febrile convulsion	6	33.33
CNS infection	4	22.22
Head injury	2	11.11
Cerebral stroke	2	11.11
Alcohol drinking	1	5.56
Hypomagnesemia	1	5.56
Moya Moya like disease	1	5.56
Neurofibromatosis	1	5.56
Total	18	100.00

Table 5. Clinical diagnosis as localization versus age groups

Clinical diagnosis vs. age group (yr)	15-34 yr	35-64 yr	Over 64 yr	Total
Extratemporal lobe epilepsy (ETLE)	14 (15.38%)	17 (18.68%)	3 (3.30%)	34 (37.36%)
Unclassified ETLE	5 (5.49%)	10 (10.99%)	1 (1.10%)	16 (17.58%)
Frontal lobe epilepsy	6 (6.60%)	6 (6.60%)	2 (2.20%)	14 (15.38%)
Parietal lobe epilepsy	2 (2.20%)	0 (0.00%)	0 (0.00%)	2 (2.20%)
Occipital lobe epilepsy	1 (1.10%)	1 (1.10%)	0 (0.00%)	2 (2.20%)
Focal epilepsy, unclassified lobe	17 (18.68%)	11 (12.09%)	4 (4.40%)	32 (35.16%)
Temporal lobe epilepsy	5 (5.49%)	4 (4.40%)	2 (2.20%)	11 (12.09%)
Others	4 (4.40%)	8 (8.79%)	2 (2.20%)	14 (15.38%)
Provoked seizure	3 (3.30%)	3 (3.30%)	0 (0.00%)	6 (6.60%)
Convulsive syncope	0 (0.00%)	2 (2.20%)	2 (2.20%)	4 (4.40%)
Probably seizure	0 (0.00%)	3 (3.30%)	0 (0.00%)	3 (3.30%)
Gelastic seizure	1 (1.10%)	0 (0.00%)	0 (0.00%)	1 (1.10%)
Total	40 (43.96%)	40 (43.96%)	11 (12.09%)	91 (100.00%)

epilepsy, it was undetermined or non-specific in eight patients (8.79%) and was classified as an idiopathic group. Multiple abnormalities were found in twelve patients (13.19%). In eight of these 12 patients, cortical dysplasia was found coincident with MTS. The details of the disease in each disease category are demonstrated in Fig. 1.

Out of the 10 patients (10.99%) in the congenital disease category, eight patients (80%) had cortical dysplasia (Fig. 2) and two patients (20%) had arachnoid cysts. There were four patients (4.40%) in the traumatic group-3 (75%) were post surgical encephalomalacic change and the other one (25%) was post radiation change.

Among the 15 patients (16.48%) in the vascular group, six patients (40%) had cerebral infarction (Fig. 3), four patients (26.67%) had vasculitis (Fig. 4), two patients (13.33%) had superior sagittal sinus (SSS) thrombosis (Fig. 5) and the other three patients had hypoxic ischemic encephalopathy (HIE), bleeding cavernoma and Moya-Moya like disease respectively.

Among the seven patients (7.70%) in the tumor group, two patients (28.57%) had oligodendroglioma, two patients (28.57%) had malignant oliogodendroglioma, one (14.29%) had mixed malignant oligodendroglioma and astrocytoma, one (14.29%) had meningioma (Fig. 6) and the other one (14.29%) had cerebral metastasis from non-Hodgkin lymphoma.

Among the eight patients (8.79%) with CNS infection, herpes encephalitis (Fig. 7) was found in three patients (37.50%) and chronic granulomatous infection was found in two patients (25.00%). In addition, one HIV encephalopathy, one diffuse viral meningoencephalitis (undetermined pathogen) and one CNS cysticercosis were found.

In the present study, MTS (Fig. 8) was the most common cause of epilepsy in the overall popula-

Table 6. Structural abnormality localization

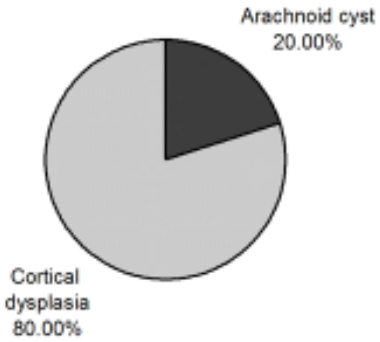
Abnormal location (MRI)	No.	Percent
Temporal lobe	60	45.45
Frontal lobe	27	20.45
Parietal lobe	18	13.64
Occipital lobe	7	5.30
Diffuse	7	5.30
Nonspecific	5	3.79
Cerebellum	3	2.27
Superior sagittal sinus	2	1.52
Basal ganglia	2	1.52
Brainstem	1	0.76
Total	132	100.00

Table 7. Disease categories

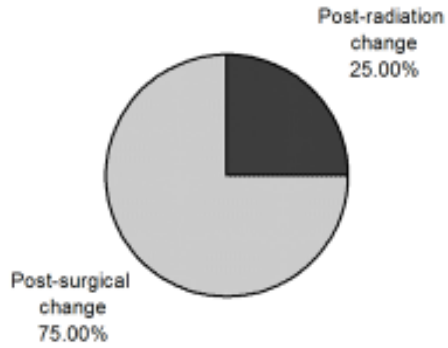
Disease categories	Diseases
1. Congenital disease	cortical dysplasia, Sturge-Weber syndrome, arachnoid cyst, and other disorders of neuronal migration
2. Trauma	accidental or following elective neurosurgery
3. Vascular	infarction, hypertensive encephalopathy, cerebral venous thrombosis, arteriovenous malformations, or post-anoxic encephalopathy
4. Neoplasm	
5. Infection	bacterial meningitis, viral encephalitis, parasitic infection, cerebral abscess or chronic viral infection, e.g. HIV
6. Mesial temporal sclerosis (MTS)	
7. Degenerative disease	Alzheimer's disease and other neurodegenerative disorder
8. Idiopathic/Others	

Table 8. Disease category classified in age groups

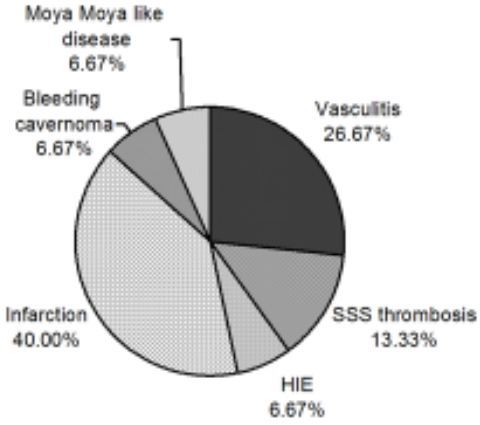
Age (yr) vs disease	MTS	Vascular	> 1 category	Congenital	Infection	Idiopathic	Neoplasm	Trauma	Total
15-34 yr	11 (12.09%)	4 (4.40%)	7 (7.70%)	8 (8.79%)	4 (4.40%)	3 (3.30%)	3 (3.30%)	2 (2.20%)	42 (46.15%)
35-64 yr	14 (15.38%)	8 (8.79%)	5 (5.49%)	2 (2.20%)	4 (4.40%)	2 (2.20%)	4 (4.40%)	2 (2.20%)	41 (45.05%)
Over 64 yr	2 (2.20%)	3 (3.30%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (3.30%)	0 (0.00%)	0 (0.00%)	8 (8.79%)
Total	27 (29.67%)	15 (16.48%)	12 (13.19%)	10 (10.99%)	8 (8.79%)	8 (8.79%)	7 (7.70%)	4 (4.40%)	91 (100.00%)



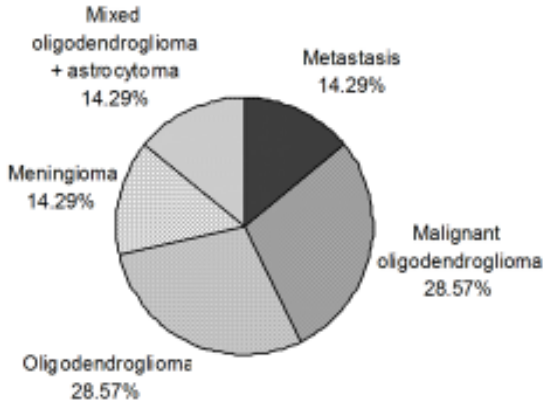
A: Congenital



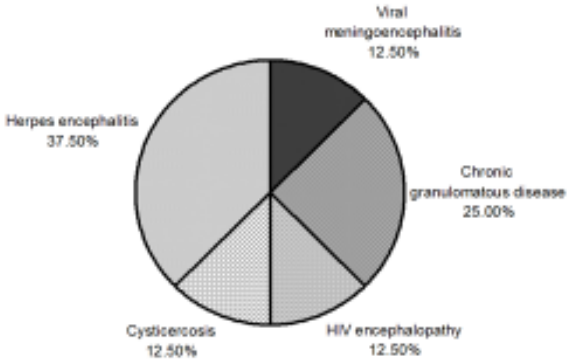
B: Trauma



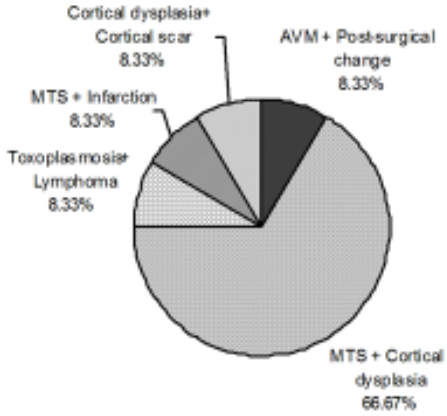
C: Vascular



D: Tumor



E: Infection



F: Combined etiologies

Fig. 1 Disease categories and disease details

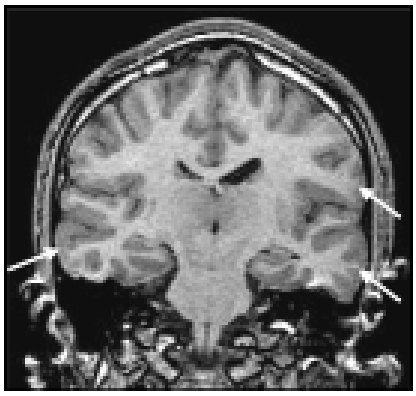


Fig. 2 A 20-year-old male with epilepsy. Coronal T1-weighted inversion recovery MR image shows diffuse thickening of the cortical gray matter with bumpy lumpy pattern of bilateral temporal lobes, representing cortical dysplasia

tion and in temporal lobe epilepsy, which was found in 27 patients (29.67%) and eight patients (72.73%), respectively. The adult patient (35-64 years) age group was commonly affected (14 patients, 51.85%).

Regarding disease categories classified in each age group, among 42 patients of young adult age group (15-34 years old), mesial temporal sclerosis was the most common cause of epilepsy (11 patients, 26.19%). Congenital disease category was the second most common cause (8 patients, 19.05%). MTS and vascular disease were the two most common causes of epilepsy in adult patients (35-64 years old), found in 14 patients (34.15%) and eight patients (19.51%), respectively. In older patients (over 64 years old), vascular disease and idiopathic pathology were the common etiologies of epilepsy, which were found in three patients (37.50%) in each group. Fig. 9, 10, and 11 showed the disease categories classified in each age group.

Among the 91 patients with epilepsy, 33 patients (36.26%) had EEG performed before performing the MRI study. Normal EEG was found in 17 cases (51.52%), and abnormal EEG was found in 16 cases (48.48%). Statistical analysis (Kappa analysis) showed that the EEG findings were concordant with the MRI findings with statistical significance (p-value = 0.0001). The clinical data (history and physical examination) and MRI were concordant with statistical significance (p-value < 0.0001). The clinical data and EEG were also concordant with statistical significance (p-value < 0.0001). The details are shown in Table 9.

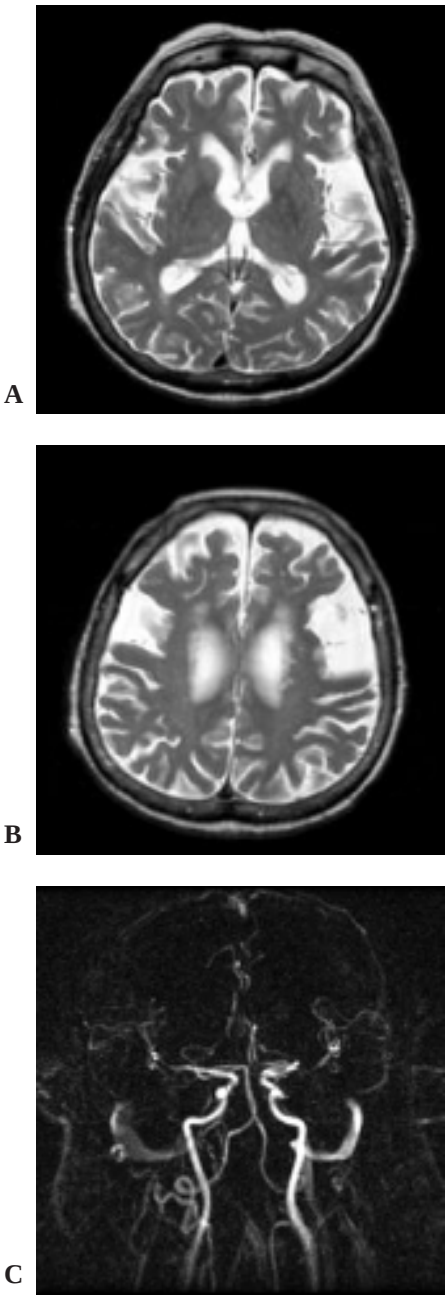


Fig. 3 An 85-year-old female with focal seizure of the left hand
A, B. Axial T2-weighted MR images show moderate bilateral frontal cortical atrophy with hypersignal T2 change at bilateral anterior frontal and temporal areas, suggestive of cerebral cortical ischemia
C. MR angiography shows marked narrowing of bilateral horizontal middle cerebral arterial branches-distal to MCA bifurcation, representing atherosclerotic changes

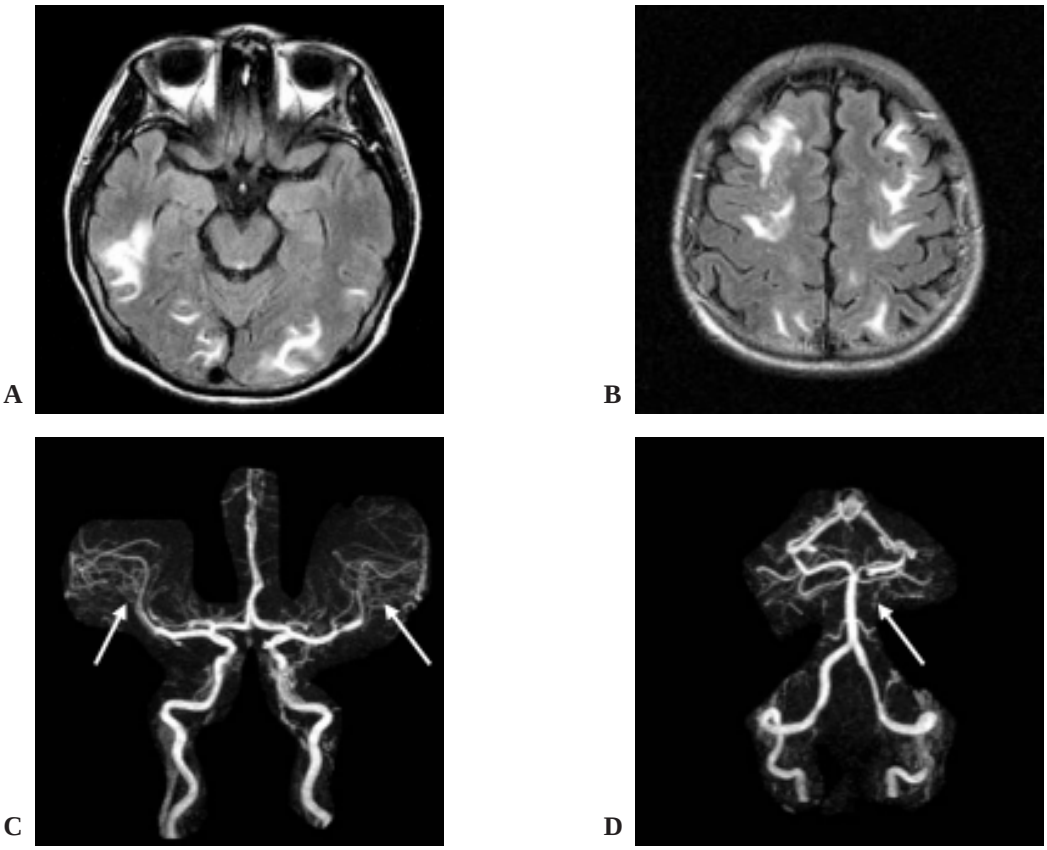


Fig. 4 A-D MR images and MR angiography (MRA) of a 20-year-old female with underlying IgM nephropathy:
A and B, Fluid-attenuated inversion recovery (FLAIR) MR images in axial plane show multifocal areas of high signal intensity involving the cortical gray and subcortical white matter of bilateral cerebral hemispheres
C and D, MRA of the brain reveal multifocal moderate narrowing of the segmental branches of bilateral middle cerebral arteries and the left posterior cerebral artery with bead-like appearance (small arrows in C and D), compatible with vasculitis

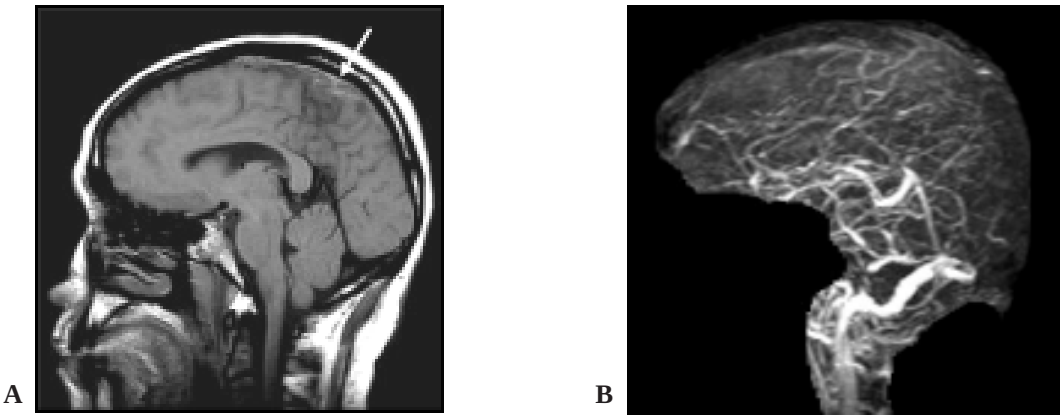


Fig. 5 Superior sagittal sinus thrombosis in a 37-year-old female with no underlying disease
A. Sagittal T1 weighted MR image shows hypersignal T1-weighted blood clot along the course of the SSS, indicating venous sinus thrombosis (small arrow in A) which is confirmed in 2D TOF MR venography image (B) with non-visualization of the SSS

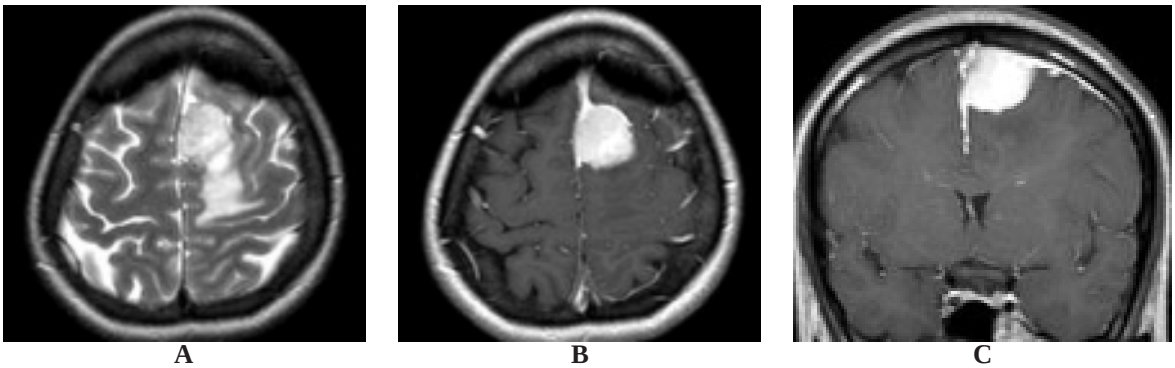


Fig. 6 A 39-year-old female with meningioma at the left parasagittal frontal convexity
A. Axial T2-weighted MR image shows a well-defined extra-axial hypersignal T2 mass with perilesional edema
B, C. Axial and coronal T1-weighted MR images after gadolinium administration show a well-defined mass with homogeneously intense enhancement.and adjacent thick dural enhancement along the anterior falx cerebri and the left frontal-dura (dural tail's sign)

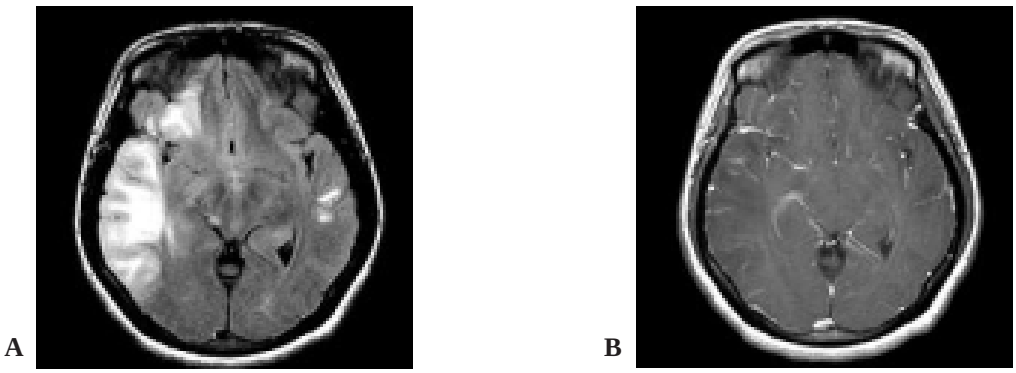


Fig. 7 A 25-year-old HIV infected female with Herpes encephalitis
A. Axial FLAIR MR image in axial plane shows abnormal thickened cortical gray and subcortical white matter with hypersignal T2-weighted change involving mainly the right temporal lobe, the right subfrontal region and much less degree at the left temporal lobe
B. Axial T1-weighted MR image after gadolinium administration shows diffuse leptomeningeal enhancement (more pronounced on the right side)

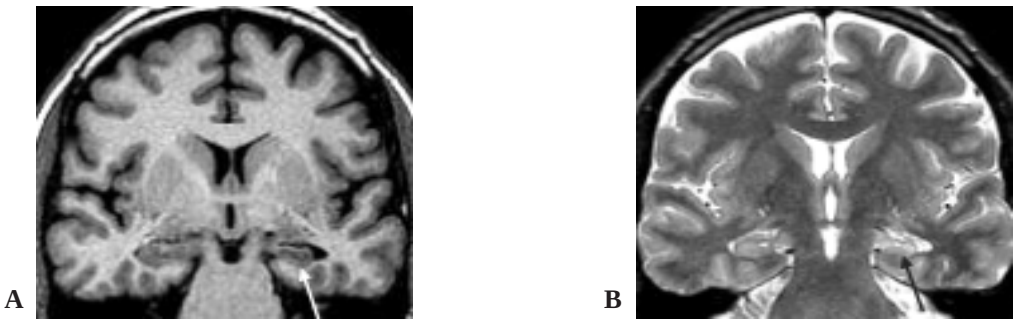


Fig. 8 A 36-year-old female with epilepsy, EEG was not performed
A and B. Coronal T1-weighted inversion recovery and Coronal T2-weighted MR images show severe left mesial temporal sclerosis evidenced by severe atrophy and hypersignal T2 change of the left hippocampus (small arrow)

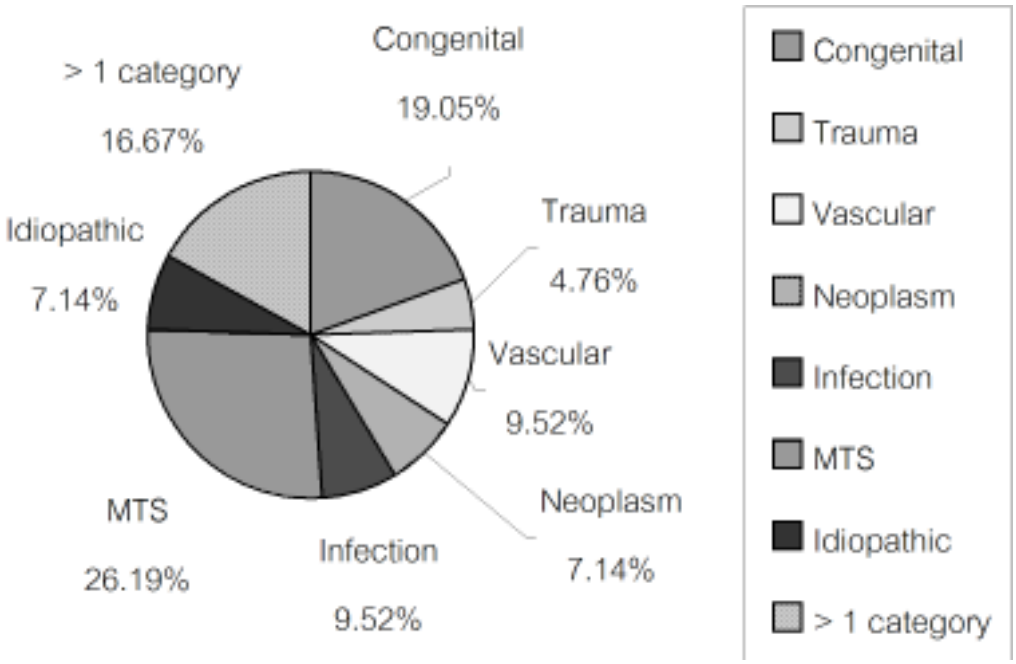


Fig. 9 Causes of epilepsy in the young adult age group (15-34 years old)

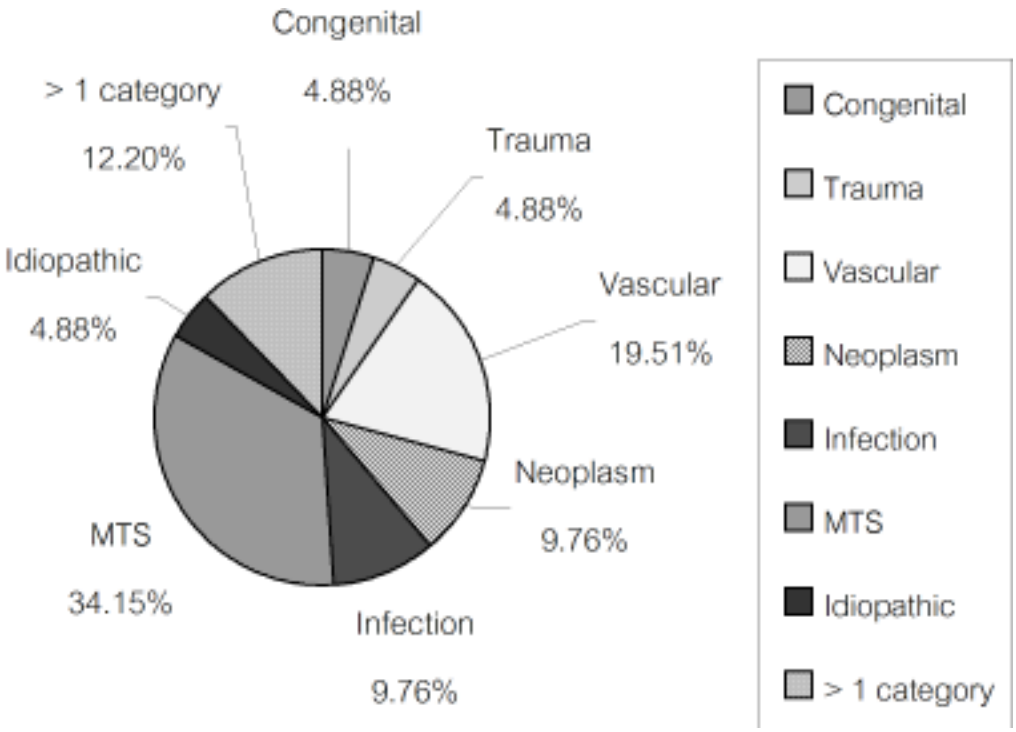


Fig. 10 Causes of epilepsy in the adult age group (35-64 years old)

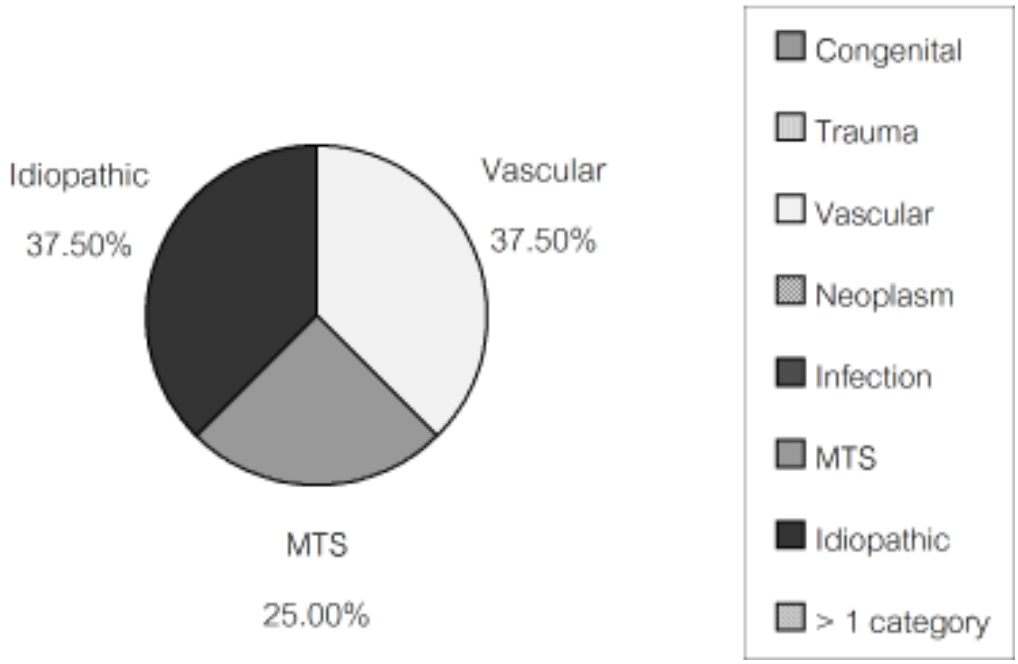


Fig. 11 Causes of epilepsy in the old age group (over 64 years old)

Table 9. Percentage of agreement among MRI, clinical data and EEG findings

Agreement	% of agreement	Kappa value	p-value
MRI vs EEG	30.30	0.1951	0.0001
MRI vs clinical	59.34	0.5058	<0.0001
EEG vs clinical	33.33	0.2500	<0.0001

Discussion

Epilepsy investigations in adult patients include EEG and MRI. MRI is the modality of choice for detection of cerebral structural abnormality or epileptogenic foci[11-13]. In the present study, MRI, clinical data, and EEG were collected and analyzed. EEG was performed in only 36.26% of all patients and half of them showed a normal EEG finding. Clinically, secondary generalized tonic clonic seizure and complex partial seizure were the most common presenting seizure types. Extra temporal lobe epilepsy was the most common clinical diagnosis. Therefore, only clinical history and physical examination could not identify definite pathological location in the brain. Although the percentage of agreement between the MRI and EEG findings was only 30.30%, the p-value showed statistical significance (p-value = 0.0001) due to high percentage (51.52%) of normal EEG, whereas MRI can detect abnormalities in most of these patients. MRI was more sensitive than EEG in detecting abnormal lesions in epileptic patients. However, in some situations, EEG had the potential to provide accurate localization of the site of epileptogenesis in foreign tissue lesions[9] and to confirm the suspected lesion detected on MRI or the location suspected from clinical history. The EEG and clinical data as well as MRI and clinical data, were also concordant.

Mesial temporal sclerosis (MTS) was the most common cause of epilepsy in overall patients and in temporal lobe epilepsy. The disease is diagnosed where atrophy and high T2 signal intensity of the hippocampus were present.

The incidences of underlying cause of epilepsy in each age group were different. In the young adult age group, MTS was the most common cause, followed by congenital disease (i.e., cortical dysplasia), whereas the study of Rochester[10] showed that trauma (exception for idiopathic cause) was the most common cause.

For the adult age group, MTS was the most common cause followed by vascular disease (infarction, vasculitis and venous sinus thrombosis), while the study of Rochester[10] revealed that besides idiopathic cause, vascular disease was the most common cause.

In the older age group, vascular disease and idiopathic causes were equally common etiologies of epilepsy, compared to the study of Rochester[10], which showed that vascular disease was the main etiology after idiopathic cause.

The discrepancy between the present study and the study of Rochester[10] may be due to the difference in study population recruited. The present study recruited all patients who had MRI study performed with dedicated protocol, while the Rochester study recruited the epileptic patients from the clinical aspect and not all of them had MRI done.

The present study represents the etiologies of epilepsy in a selected group of patients who had been sent for MRI study only, not representing all epileptic patients in Thailand.

At present, higher magnetic field-strength (3 Tesla) and new MRI techniques provide a higher signal-to-noise ratio (SNR), reduction of the acquisition time and improvement of spatial resolution and accuracy of the diagnosis[14,15]. MR spectroscopy and functional MRI can assess the metabolites of the epileptogenic foci and localization of the cognitive and sensorimotor function for a surgical treatment plan[14-16].

Conclusion

MRI should be the imaging technique of choice for evaluation of patients with epilepsy or seizure. It can demonstrate the structural brain lesion in correlation with the clinical data and EEG for accurate localization of the abnormality.

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ภาพถ่ายสมองด้วยคลื่นแม่เหล็กไฟฟ้าในผู้ป่วยโรคลมชัก (ผู้ใหญ่): ประสบการณ์ในโรงพยาบาลรามาธิบดี

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วัตถุประสงค์: *เพื่อศึกษาความผิดปกติของสมองในผู้ใหญ่ที่เป็นโรคลมชักจากภาพถ่ายสมองด้วยคลื่นแม่เหล็กไฟฟ้า (MRI) ร่วมกับหาความสัมพันธ์กับอาการแสดงของผู้ป่วยและผลการตรวจด้วยคลื่นไฟฟ้าสมอง (EEG)*

วัสดุและวิธีการ: *โดยการเก็บข้อมูลย้อนหลังของผู้ป่วยโรคลมชักที่ได้รับการตรวจสมองด้วยคลื่นแม่เหล็กไฟฟ้า (MRI) ในโรงพยาบาลรามาธิบดี ตั้งแต่เดือนมกราคม พ.ศ. 2544 ถึงเดือนธันวาคม พ.ศ. 2545 จำนวน 91 ราย ซึ่งมีอายุตั้งแต่ 15 ปี ถึง 85 ปี (อายุเฉลี่ย 36.98 ปี) และได้จำแนกความผิดปกติเป็น 8 กลุ่มตามสาเหตุของการเกิดโรค จากนั้นได้นำข้อมูลมาหาความสัมพันธ์กับอาการแสดงของผู้ป่วยและผลการตรวจด้วยคลื่นไฟฟ้าสมอง (EEG) โดยใช้การวิเคราะห์เชิงสถิติ*

ผลการศึกษา: *การชักแบบ secondary generalized tonic clonic seizure เป็นอาการชักที่พบบ่อยที่สุด และ extra-temporal lobe epilepsy เป็นการวินิจฉัยที่พบมากที่สุด, จากผู้ป่วยจำนวน 91 ราย มีเพียง 33 รายที่ได้รับการตรวจคลื่นไฟฟ้าสมอง (EEG) โดย 17 รายผลเป็นปกติ, ผลการตรวจสมองด้วยคลื่นแม่เหล็กไฟฟ้า (MRI) พบความผิดปกติที่ temporal lobe มากที่สุด โดย mesial temporal sclerosis เป็นสาเหตุการชักที่พบมากที่สุด, เมื่อแยกตามกลุ่มอายุในกลุ่มผู้ป่วยผู้ใหญ่ตอนต้น (อายุ 15-34 ปี) ความผิดปกติที่พบมากที่สุดคือ mesial temporal sclerosis รองลงมาคือ cortical dysplasia, ในกลุ่มผู้ป่วยผู้ใหญ่ตอนกลาง (อายุ 35-64 ปี) พบ mesial temporal sclerosis มากที่สุด รองลงมาคือโรคเกี่ยวกับระบบหลอดเลือด (vascular disease), และในกลุ่มผู้สูงอายุ (อายุมากกว่า 64 ปี) พบโรคเกี่ยวกับระบบหลอดเลือดและที่ไม่สามารถหาสาเหตุได้จำนวนเท่ากัน, จากการหาร้อยละที่ความสอดคล้องระหว่าง MRI, กับอาการแสดงและ EEG พบว่าตัวแปรทั้งสามมีความสัมพันธ์ซึ่งกันและกัน*

สรุป: *การตรวจสมองด้วยคลื่นแม่เหล็กไฟฟ้า (MRI) เป็นการตรวจพิเศษที่สามารถวิเคราะห์ความผิดปกติทางกายวิภาคของสมองได้โดยละเอียด และข้อมูลที่ได้มีความสัมพันธ์กับอาการแสดงและ EEG, ดังนั้น MRI จึงเป็นการตรวจที่มีความสำคัญในการประเมินผู้ป่วยโรคลมชัก*