

ศูนย์โรคลมชักคณะแพทยศาสตร์โรงพยาบาลรามาธิบดี Ramathibodi Multidisciplinary Epilepsy Center (RMEC)





ศูนย์โรคลมชักคณะแพทยศาสตร์โรงพยาบาลรามาธิบดี Ramathibodi Multidisciplinary Epilepsy Center (RMEC)

Ictal EEG patterns in adult focal epilepsies

Apisit Boongird, MD Division of Neurology, Ramathibodi Hospital

Objectives

- Scalp-recorded ictal patterns in focal epilepsies
- How to read and identify the ictal EEG patterns in focal epilepsies?
 - basic concepts for neurology residents, fellows, nurses, and EEG technicians

Seizure

• Definition of a seizure

- An epileptic seizure is a <u>transient</u> occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain.

Seizures

- When did the seizure <u>start</u>?
- When and how did the seizure <u>spread</u>?
- When did the seizure <u>stop</u>?

Operational (practical) clinical definition of epilepsy

- Epilepsy is a disease of the brain defined by any of the following conditions
 - 1. At least two unprovoked (or reflex) seizures occurring > 24 h apart
 - 2. One unprovoked (or reflex) seizure and a probability of further seizures similar to the general recurrence risk (at least 60%) after two unprovoked seizures, occurring over the next 10 years
 - 3. Diagnosis of an epilepsy syndrome
- Epilepsy is considered to be resolved for individuals who had an age-dependent epilepsy syndrome but are now past the applicable age or those who have remained seizure-free for the last 10 years, with no seizure medicines for the last 5 years.

Focal seizure

• Focal epileptic seizures are conceptualized as originating within networks limited to one hemisphere. They may be discretely localized or more widely distributed. Focal seizures may originate in subcortical structures.

Clinical data



EEG data

1030



Sensible electrical field

Physiological artifacts	Non-physiological artifacts
Eye	EEG instrument
- Eye movements	- Power line
- Eye flutter	- Magnetic field
	- Electronic components
Heart	
- EKG	Recording electrode
- Pacemaker	- Electrode placement
	- Electrode movement
Muscles	
- Lateral rectus spikes	Environment
- Swallowing	- IV drip
- Chewing	
- EMG	
Physiological movements	
- Limb movements	
- Head tremors	





Clinical manifestations of adult focal epilepsies

- From clinical perspective, focal seizure attacks may be undetermined and is not easily noticed.
 - subjective symptoms
 - visual aura
 - tingling sensation
 - objective symptoms
 - tonic seizure
 - myoclonic jerks



- Interictal EEG
- Ictal EEG
- Postictal EEG

Guidelines of the International Federation of Clinical Physiology (EEG Suppl. 52)

Is there any standard criteria for EEG seizure onset?

• When did the seizure start and stop?

EEG findings in adult focal epilepsies

- Interictal
 - Focal epilepsies typically have ictal patterns that are distinctly different from their interictal activity.
- Ictal
- Ictal onset pattern in focal epilepsies are variable.
- In scalp EEG recordings, partial seizures may not have a clear EEG correlate. *

Case#1:

- A 34 yo female with drug-resistant temporal lobe epilepsy who is here for seizure evaluation.
- MRI: cystic encephalomalacic changes at right anterior temporal lobe



Case#1:

• EEG: interictal on both sides(left 70%, right 30%)

7-13 2 0 3-15 5-01 n2-F8 F8-T4 6 m 14-16 T6-02 5p1-F E3-C3 11 53-P3 P3-01 12 % Ep2-E 13 E4-C4 14 1 1 C4-P4 15 M P4-0 16 1 Fz-L Cz-Pz 18 -X1-X2 ECG 19 Sharp Wave F7 Shatp wave right temporal 14

• VEEG: EEG seizure onset on right hemisphere

• Frequent interictal epileptiform discharges are usually not associated with clinical seizures and thus should be differentiated from electroencephalographic seizure patterns.

Electrographic evolution of a focal-onset seizure

- The electrographic evolution of a focal-onset seizure commonly includes one or more of the following features:
 - frequency
 - amplitude
 - distribution
 - waveform morphology



Common EEG patterns at the start of seizures in patients with epilepsy

1. rhythmical evolving theta, delta, alpha frequencies

- 2. rhythmic spiking
- 3. spike-waves
- 4. electrodecremental

5. clinical seizure with no significant EEG changes

Focal-onset seizure

- localized ictal EEG

- lateralized ictal EEG

Focal- onset seizure with spreading patterns

- lateralization of ictal EEG

- diffuse ictal pattern without lateralization
- asynchronous and independent rhythms on both cerebral hemispheres
- switch of lateralization" from the hemisphere of origin to the contralateral side

Secondary generalization

- Synonym: secondary bilateral synchrony
- Spreading of an initially focal (regional) epileptiform discharge to become generalized. Secondary generalization frequently occurs from midline frontal generators.

Postictal EEG in focal epilepsies

• Postictal symptoms

- observation for any lateralizing signs

• Postictal EEG changes

- may help in identifying the seizure focus

Reading the adult EEG

- Check the patient name, age, and hospital number
- Reasons for EEG study
- Open the file (date of EEG study)
- Choose the EEG montage
- Check the EEG setting
 - factors affecting vertical display: sensitivity(7 microvolts/mm, low frequency filter(1Hz), high frequency filter (70Hz)

- factors affecting horizontal display: time base (30 mm/second)

EEG analysis

- Preceding EEG background
- Ictal EEG

- an identifiable change from the interictal EEG background at seizure onset EEG onset which is followed by evolution in amplitude and frequency of EEG background.

• Postictal EEG

- termination of ictal EEG



Classification of seizures

- I. Partial (focal) seizures
 - A. Simple partial seizures (consciousness not impaired)
 - B. Complex partial seizures (consciousness impaired)
 - C. Partial seizures evolving to secondarily generalized seizures
- II. Generalized seizures of non-focal origin
 - A. Absence seizures ('petit mal')
 - B. Myoclonic seizures; myoclonic jerks (single or multiple)

Epilepsia. 2010 Apr;51(4):676-85.

- C. Tonic-clonic seizures ('grand mal')
- D. Tonic seizures
- E. Atonic seizures
- III. Unclassified epileptic seizures

Simple partial seizures

- In most cases, simple partial seizures are not associated with scalp EEG changes. This has been shown to occur in 60% to 80% of simple partial seizures.
- In one study, the EEG changes in simple partial seizures could be reliably observed in 20% of the patients. *
- A normal EEG is common during simple partial seizures and does not exclude the diagnosis of epilepsy.

Case#2: simple partial seizures

A 22yo left-handed female presents with recurrent seizures.

Seizure type1: left hand and arm tonic with preserved awareness - more than 10 per month

- continuous seizures for 3-4 days during menstruation

Seizure type 2: left hand and arm tonic \rightarrow GTCs - last GTCs was a year ago.

Current meds: PHT, LEV

Past AED: CBZ, clobazam

PET: hypometabolism at right parietal lobe

Case#2: interictal EEG



Case#2: interictal EEG

[SENS 7	7 HF 70 LF 0.53 C	CAL 50]			
1 Fp1-F7	muse manustration of	municanerson	variante and and an and an and an and	man when the man and the second	a more and a more and
2 F7-T3	www.mannewww.	www.www.www.www.www.	norman	munimation	me man man providence and the second
3 T3-T5	when man with more	warman	monorman	oninionini	www.www.www.www.www.www.www.www.www.ww
4 T5-01	winnin	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
5 Fp2-F8	1 management		manufactor and a second manufactor	mound	hannan
6 F8-T4	manohennen vormanter	warmen warmen and warmen a	warman and the management	any man and and and and and and and and and a	warmen warmen and
7 T4-T6	marianonomono	agraman and	moment when the sources	mour warman work	Mannenser
8 T6-O2			······	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	www.
9 Fp1-F3	man marken mark	www.www.	Minuman munuman	and in the man and a second second	www.www.www.www.
10 F3-C3	mmumm	muninin	mmmmmmmm	withinknowhen the	m munimum
11 C3-P3	·····	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	·····	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
12 P3-01	www.www	mmmm	mmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm	m.m.m.m.m.m.m.m.m.m.m.m.m.m.m.m.m.m.m.	mmmm
13 Fp2-F4	1 million and many	montering	minimum minder mana	and interview of the second of	- Mary What was
14 F4-C4	mmm	mmm	mmmmm	mmm	mmmmm
15 C4-P4	man	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	man	man www.www.www.	Mannaham
16 P4-O2	mun	mannen	man have	mmmmm	hummun
17 Fz-Cz	mmmmm	man mining	minimum	mmmmm	mmmmmm
18 Cz-Pz	mmmmmm	mm Minning M	Multiment	- Marine Marine	monorm
19 <i>0V-X2</i>	I C C		slow right P4	Slow Wave	
м					

Case#2: seizure

[SENS 7 H	IF 70 LF 0.53 CAL 50]
1 Fp1-F 7 ∞√	- the manufacture and the second and
2 F7-T3 ^{504V}	man man and the second of the
3 T3-T5 ^{504V}	mun man man man man man man man and the second of the seco
4 T5-O150⊌V	and manus with a support of the supp
5 Fp2-F8º	
6 F8-T4 ^{50UV}	man man man and the man was a second of the
7 T4-T6 ^{50UV}	man when when the second when the second sec
8 T6-O2 ^{50UV}	and the second of the second o
9 Fp1-F3 ³ ₩	American manual manual manual and a second a
10 F3-C3 ^{50,JV}	wanter
11 C3-P3 ^{504V}	which and the second of the se
12 P3-O1 ^{50JV}	remains when when when we we we want the second of the second sec
13 Fp2-F4 ⁰	manufacture and the second and the s
14 F4-C4 ^{50UV}	Martin
15 C4-P4 ^{50JV}	manner when a second when a second when a second when we have a second when when we have
16 P4-O2 ^{50.//}	www.www.www.www.agagagagagagagagagagagag
17 Fz-Cz 504V	when we
18 Cz-Pz 50./V	ECG
19 <i>0V-X2</i> ∞.√ M	left arm tortic

Case#2: 10 seconds later





- A 55 yo male with past medical history of CA esophagus, right MCA infarction with symptomatic carotid stenosis who presents with 1st episode of EPC.
- Seizure type1: continuous and periodic clonic movement on left upper and lower extremity with left Todd paralysis
- Current meds: levetiracetam

• The failure of scalp recordings to detect activity from a focal seizure may be explained by the seizure's distant location, limited extent, or disadvantageous orientation with respect to scalp electrodes.
Limited electrode coverage by using standard 10-20 system

- orbitofrontal cortex

- mesial frontal area

- basal temporal area





ขอขอบคุณ คุณชนะ

Neurology. 1989 Apr;39(4):527-33.

Closed field

vs Open field



Complex partial seizures

• Ictal EEG change is relatively common in patients with complex partial seizure.

• An absence of a change on scalp EEG during complex partial seizures is most commonly seen in patients with frontal lobe epilepsy.

Case#4:

A18 yo right-handed female with past medical history of epilepsy and febrile seizure who is referred from an OSH for the evaluation of drug-resistant epilepsy. The history of seizure began at the age of 12.

Seizure type1: complex partial seizure (abnormal behavior and loss of awareness) Seizure frequency: 1-2 times per day Seizure duration: 1-2 minutes

Current AEDs: LTG, LEV

Past AEDs: PHT, CBZ, VPA, acetazolamide, ZNS, LCS

MRI brain: left mesial temporal sclerosis

Underwent for left temporal lobectomy(Mar2016).

Pathology shows left mesial temporal sclerosis(MTS).

No seizure since epilepsy surgery.



Case#4:EEG onset



Case#4: 10 seconds later



Case#4: 20 seconds later



Case#4: 30 seconds later



Case#4: 40 seconds later



Case#4: 50 seconds later











Case#4: 80 seconds later



Case#4: 90 seconds later



Case#4: 100 seconds later









Partial seizures evolving to secondarily generalized seizures (PG)

- Secondarily generalized tonic clonic seizures are essentially always associated with a scalp EEG correlate.
- Profound postictal slowing will be identified consistently after a secondarily generalized tonic-clonic seizure.

Case#5: Partial seizures evolving to secondarily generalized seizures

A 19yo right-handed female is referred from an OSH for seizure evaluation.

Seizure type1: paresthesia of the right upper limb(10secs) → right hand tonic-clonic with preserved awareness → GTCs

freq 1/weekpostictal, she had right limb weakness

Current AEDs: LEV, OXC, LTG longest sz free was 2 months.

Past AEDs: CBZ, TPM, VPA

EEG: intermittent slow, left centro-parietal sharp wave, left parietal

Case#5: awake



Case#5: interictal

[SENS 7 คลิปบอร์ด	′HF 70 LF 0.53 เริ่สไลด์	CAL 50]	วนต์ เวเ	ย่อหน้า	G	รูปวาด	ัด การแก้ไข
1 Fp1-F7	1 mann	minimian	in the second second	minim	mining	- manufactures	montanin month
2 F7-T3	frommen	mmmmmm	an warman war	m Marine Mari	mannahan	www.howing.where we want	-ingramman for the second of the
3 T3-T5	how we want	man	when when when the second	Mundam Mariana	mmmmm	in mouth in a new man	www.www.www.www.
4 T5-01	mont	mann	manna	man	mmmmmmm		www.www.www.ww
5 Fp2-F8	1 Marthommercall Marines	man man man	with when the second states and the	raymanaamhan miraannikaan	monum prim	Word an and Ways new program with a	mpman winder and mental and a property of the second of th
6 F8-T4	forman	mmmmmm	mon man market	monorman	mound for an	water and the second se	mound
7 T4-T6	Greenworth	www.aring	an mar mar and	mannannan	mummununun	warmen warmen warden war	mmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm
8 T6-O2	www.	www.www.	mannon	mannon	monormound	www.where www.www.www.	www.www.www.www.www.www.www.www.www.ww
9 Fp1-F3	/		-	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	many /		manning
10 F3-C3	from	······	mmm	vww.www	mm fm	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	vvvv
11 C3-P3	mmm	mmm	humbu	www.www	······		Munimum
12 P3-01	mum	mmmmm	Munhow	Mummin	mound	Man Marine Marine	May Marine Marine
13 Fp2-F4	M. M	hamanaa hamaa h	man man man	Minter with the wind with the wind with	mumming mm	when we wanted and a second	approximation and a second second
14 F4-C4	Jumman	mmmm	mmm	wwwww	munder	mmmmmmmm	mmmml
15 C4-P4	furmin	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	him	mmm	mmmm	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Mar
16 P4-O2	monor	mmMvnMMm	Munnym	MMANJumen	m frank waren	ware Mander and Marian A	white the second s
17 Fz-Cz	mmm	mmm	mm	www.	mmmmm	· · · · · · · · · · · · · · · · · · ·	Manumund
18 Cz-Pz	mmmm	mmm	Mumm	mmmm	Mar Marine Ma	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Mummum
19 <i>0V-X2</i> M	ECG	Sharp W	ave SI	harp Wave		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	





Case#5: 10 seconds later



Case#5: 20 seconds later



Case#5: 30 seconds later



Case#5: 40 seconds later



Case#5: 50 seconds later



Case#5: 60 seconds later





Frontal lobe epilepsy



A 28 yo female with past medical history of frontal lobe epilepsy s/p sx(cortical dysplasia) who is here for seizure evaluation.

Seizure type1: complex motor movement with loss of awareness - freq 1-2 times per day - duration 3-5 seconds - never had GTCs

Past AEDs: PHT, CBZ, VPA, LEV, TPM, LTG

Current AEDs: VPA, GBP, LTG





Case#6:10 seconds later



Case#6:20 seconds later



Temporal lobe epilepsy

Temporal lobe epilepsy

• The features of temporal lobe epilepsy can be broken down into two broad categories.

1. mesial onset (mTLE)

2. lateral (neocortical) onset (NTLE)
| | MTLE | NTLE |
|-----------------------------|--|--|
| Suggestive clinical history | viscerosensory aura
psychic aura
oral and hand automatisms | auditory phenomena
psychic aura
visual aura
aphasia |
| Ictal EEG | focal unilateral anterior
temporal regular and
rhythmic temporal
theta or alpha activity
(typically 5-9Hz) * | Irregular, polymorphic
delta slow waves with
lateralization ** |
| Secondary generalization | slower | faster |
| | | * Neurology. 1997 Sep;49(3):757-63
**Epilepsia_ 1996 Apr;37(4):386-99. |

MTLE

- Scalp ictal EEG
 - focal unilateral anterior temporal regular and rhythmic temporal theta or alpha activity (typically 5-9Hz) is the hallmark of mTLE.

Case#7: mesial temporal sclerosis

- A 39 yo right-handed male with past medical history of left mesial temporal sclerosis who is referred here for presurgical evaluation.
- Seizure began at the age of 15.
- Seizure type 1: eye staring and loss of awareness Seizure frequency: 10 per months

Seizure type2: GTCs Seizure frequency: 5 per months

Current meds: depakine, lamotrigine, lacosamide, clonazepam

Case#7: interictal



Case#7: EEG onset



Case#7: 10 seconds later



Case#7: 20 seconds later











Case#8: Neocortical temporal lobe epilepsy

- A 63 yo right-handed male with drug-resistant epilepsy who is here for seizure evaluation.
- Sz type 1: eye staring with loss of awareness
- Sz type 2: GTCs
- Current meds: carbamazepine, lamotrigine, levetiracetam
- Past AEDs: phenytoin, phenobarb
- MRI: diffuse brain atrophy more advanced than age; right hippocampus is smaller than left hippocampus.

Case#8: EEG onset



Case#8: 10 seconds later



Case#8: 20 seconds later



Case#8: 30 seconds later



Case#8: 40 seconds later



Case#8: 50 seconds later



Case#8: 60 seconds later



Case#8: 70 seconds later



Case#8: 80 seconds later



Parietal lobe epilepsy

Parietal lobe epilepsy

- Clinical: contralateral somatosensory aura
- Ictal EEG: lateralized > localized
- VEEG: often non-localizing





Case#10:

- A 16 yo female with left occipital lobe mass s/p surgery
- Seizure Description: Her family reports that her expression changes, she can't focus and her face turns red. She then gets lip smacking, eyes deviating to right, eye fluttering with clonic jerking of right arm and leg.

Case#10:



Case#10:



Case#10: 10 seconds later



Occipital lobe epilepsy

Occipital lobe epilepsy

- Clinical: mainly visual and oculomotor symptoms
- Ictal EEG: paroxysmal fast activity, fast spiking or both, localized in the occipital regions

Case#11:

• A 12 yo right-handed boy presents with first seizure. This was happened while he was playing sports with his friends at the school. He experienced flashes in his vision of red and green light, followed by blurry vision and generalized tonic-clonic seizure.



Brain MRI showed well-defined partly solid predominantly cystic space occupying lesion at the right occipital region with invagination into the ventricular cavity.



Pathological Diagnosis: Right occipital lobe tumor, craniotomy with tumor removal: - Pilocytic astrocytoma (WHO grade I).

Cingulate epilepsy

Cingulate epilepsy

• Focal epilepsy involving cingulate is uncommon and is very difficult to differentiate from the other focal epilepsies.

Scalp ictal EEG



Primary motor, SSMA and cingulate coverage





Invasive monitoring



Seizure free for 4 +years, no AED

ขอบคุณ อ ชัยยศ และ อ อัตถพร

Conclusions

- Epilepsy is a clinical diagnosis.
- The EEG results should be interpreted in the context of the whole clinical setting.


ศูนย์โรคลมชักคณะแพทยศาสตร์โรงพยาบาลรามาธิบดี Ramathibodi Multidisciplinary Epilepsy Center (RMEC)

