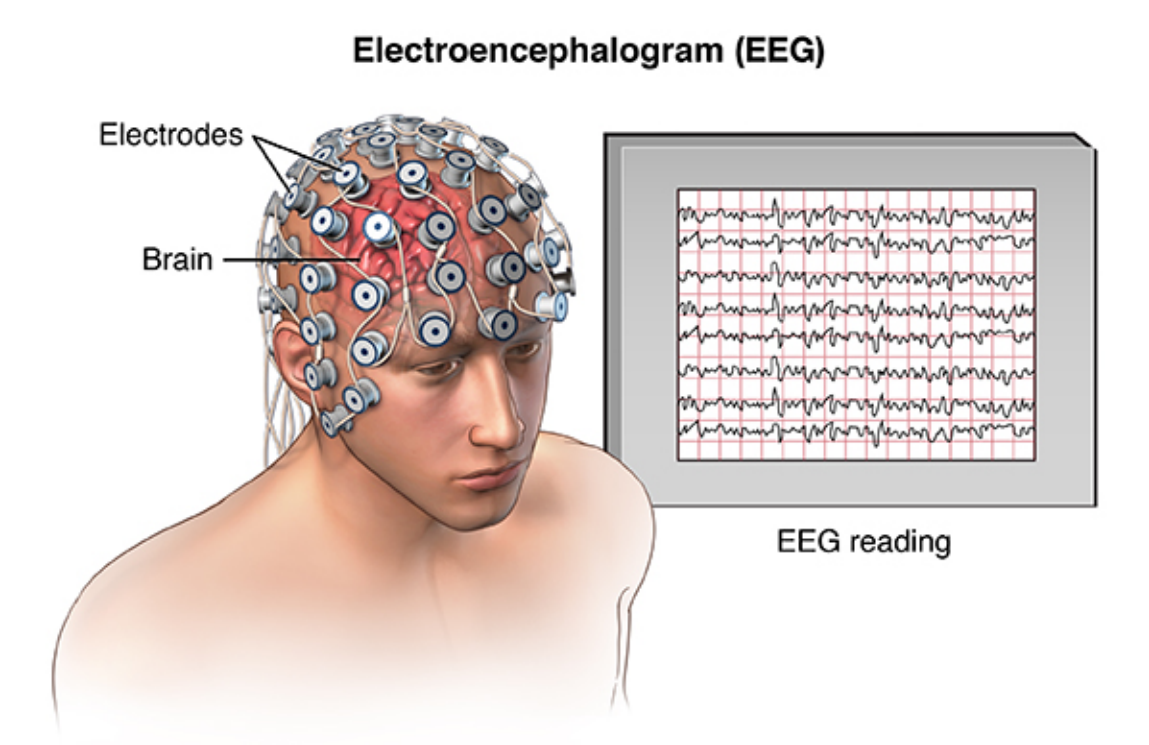
EEG in Medical Practice



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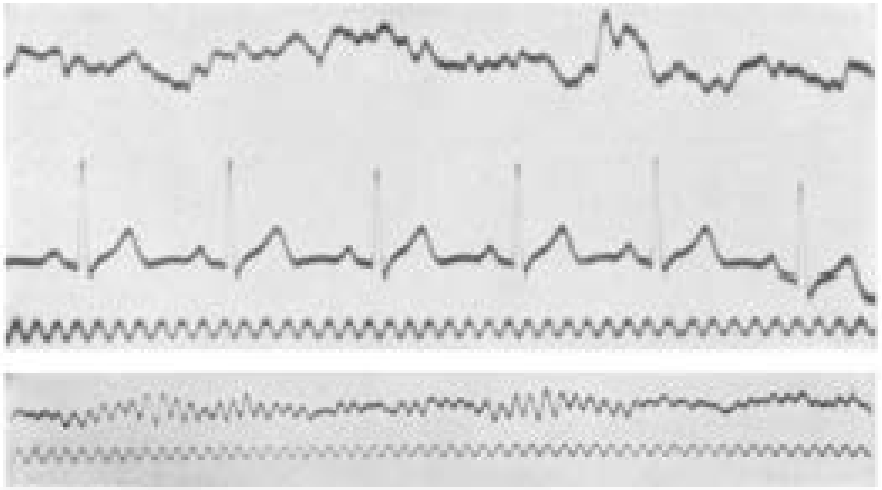
What is the EEG?

- The brain normally produces tiny electrical signals that come from the brain cells and nerves which send messages to each other.

- These electrical signals can be detected and recorded by the **EEG (electroencephalogram)** machine.

- The brain’s electrical activity is picked up by **electrodes** attached on the patient’s **scalp** and **amplified** on the EEG machine to be viewed as **brain waves**.
- it does not put any electricity **into** brain or body.

Hans Berger (1873-1941), a German psychiatrist, discovered the electroencephalography (EEG) in 1929



Analog EEG

Digital EEG

Allows more accurate interpretation of the EEG record by applying different montages/references, gain/sensitivity, filters and time constant

Use of the EEG

- **Helps to** (diagnosis)
  - **Confirm** seizures,
  - **Classify** seizures and epileptic syndrome,
  - **Quantify** seizures or epileptic bursts,
  - **Localizing** epileptic focus – especially for pre-surgical evaluation.

Use of the EEG

- Help to indicate abnormalities other then seizure:
  - Acute encephalitis/cerebral abscess
  - Brain tumour, dementia,
  - Sleep disorder,
  - Stroke,
  - Any other non-specific encephalopathy e.g. Metabolic encephalopathy
  - Brain death

What should I do to prepare for an EEG?

- Commonly there is no preparation necessary. Patient should not stop any medication take for seizures unless advised.

- But patient's hair should be clean and dry. Avoid using products such as hair gel and wax.

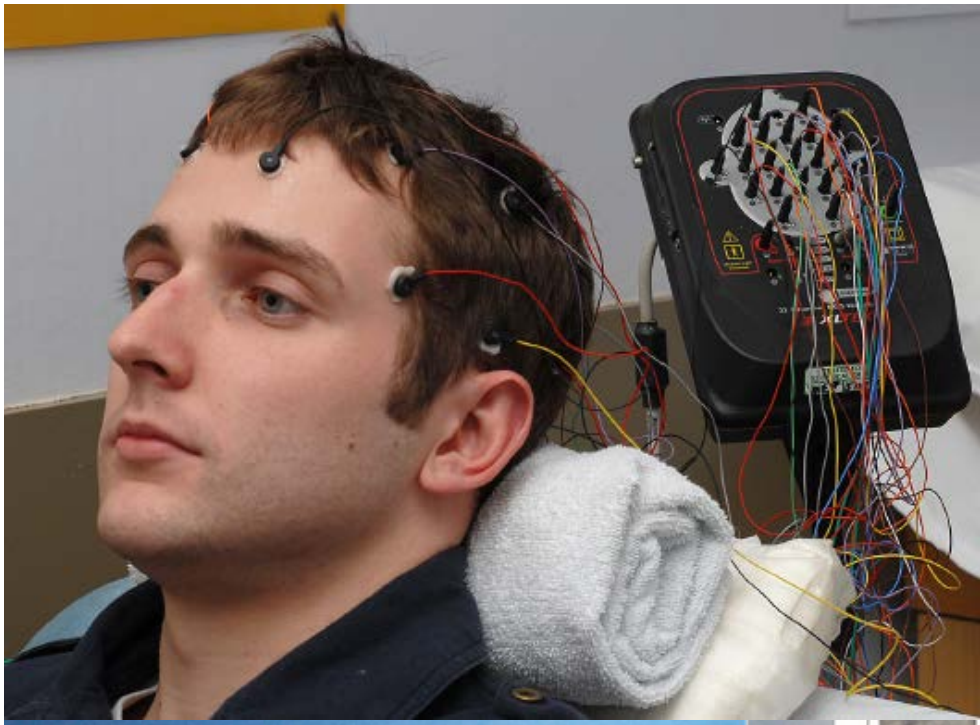
How is the test done?

- Several small patches (electrodes) attach to scalp. Wires from the electrodes are connected to the EEG machine.
- The machine detects and amplifies the electrical signals and records them on to a paper or computer.
- The test takes about 20-30 minutes.

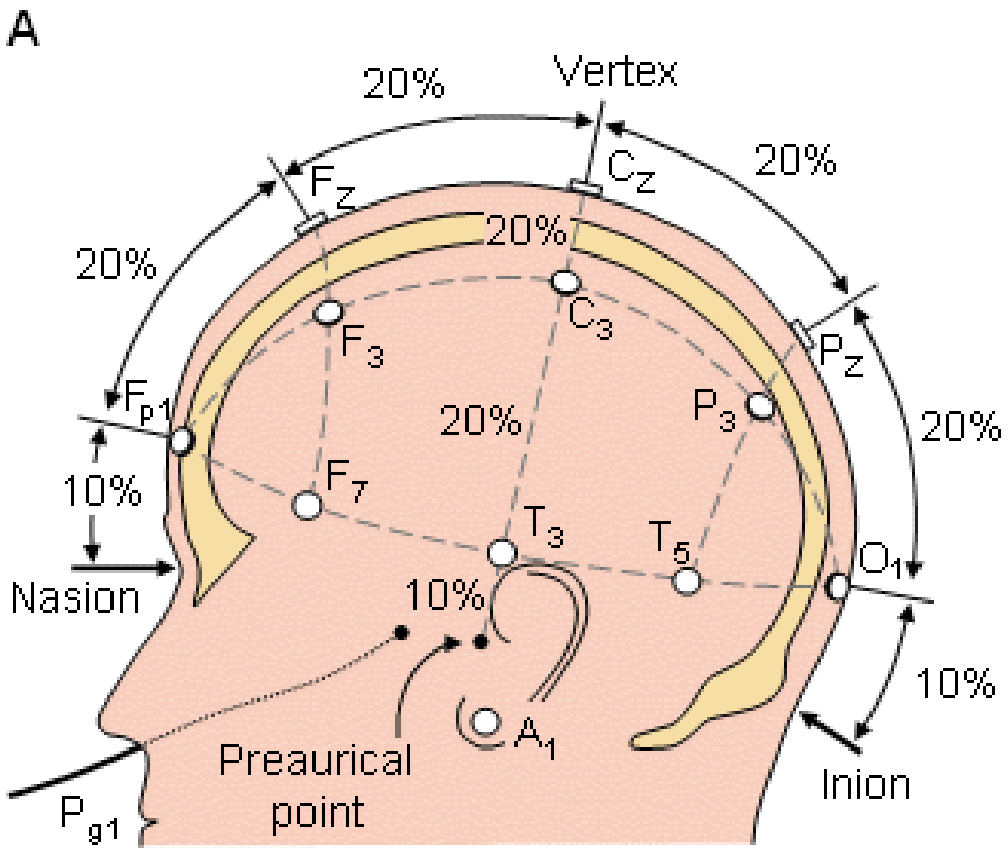
Electrode Positioning system

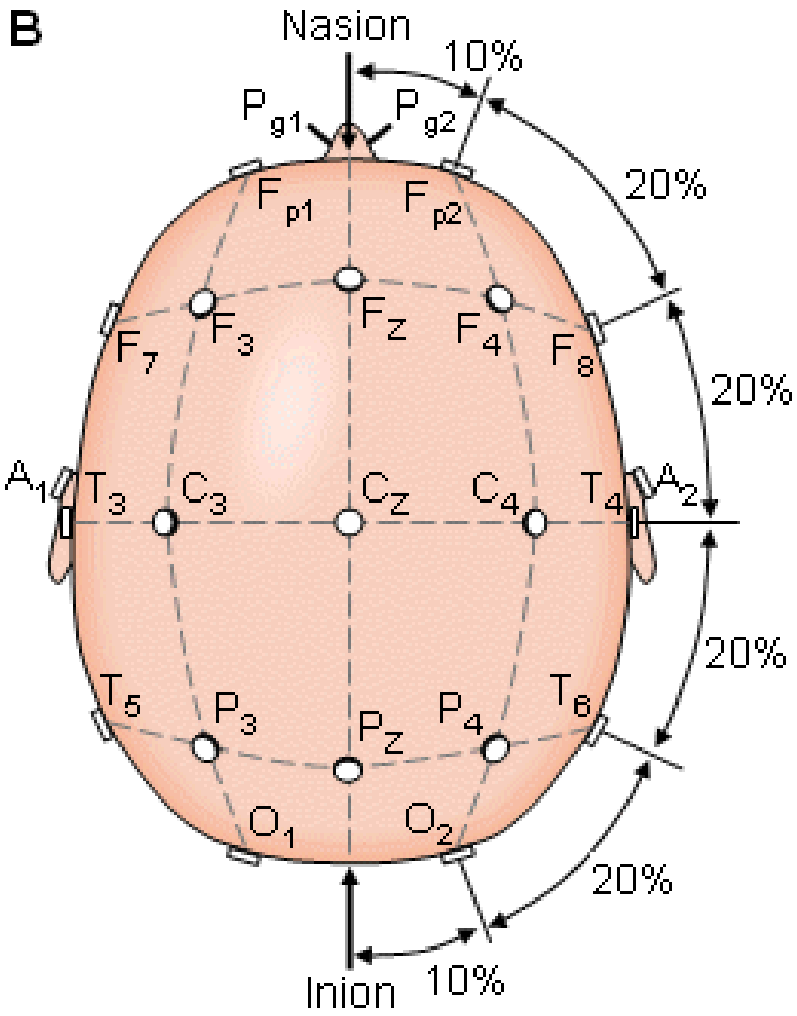
The majority of laboratories use the **10 to 20 system** of electrode placement.

(recommended by the ***International Federation of Societies for Electroencephalography and Clinical Neurophysiology)***

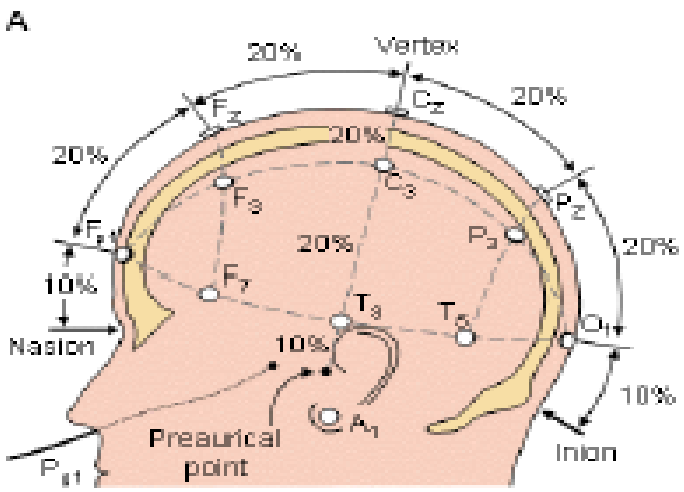


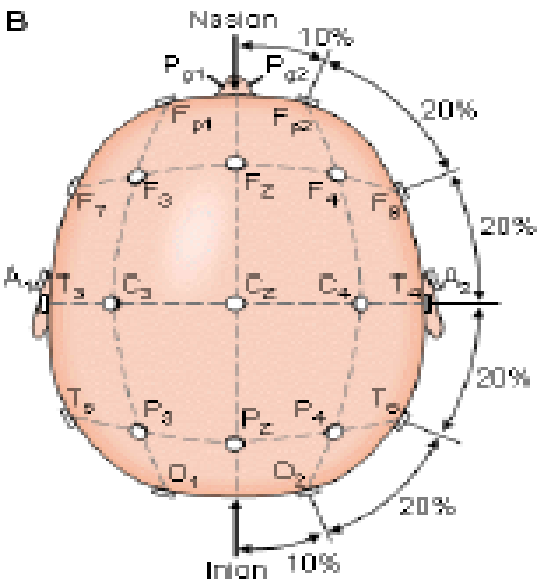
10 /20 system of EEG electrode placement

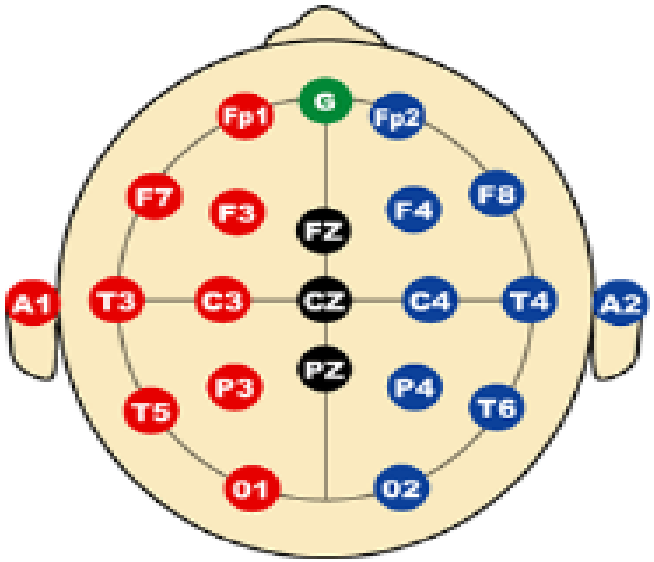




A specific scalp electrode is denoted by an alphabet followed by a number.







Electrode Placement

International 10-20 System

Fp1 = left frontal pole

F3 = left frontal

F7 = left fronto-temporal

C3 = left central

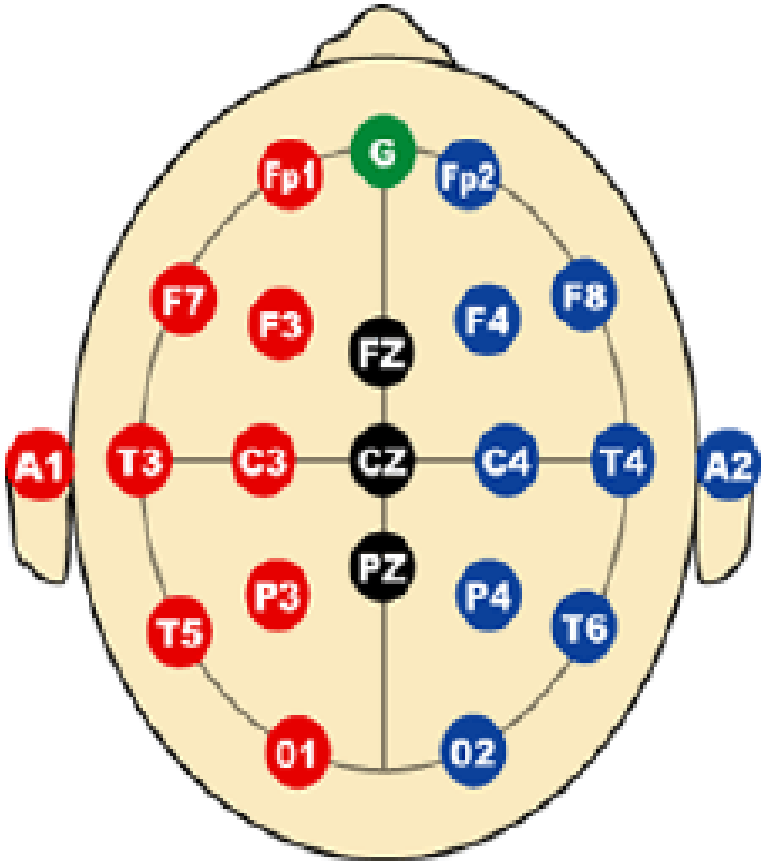
T3 = left temporal

P3 = left parietal

T5 = left postero-temporal

O1 = left occipital

A1 = reference to left year



Fp2 = right frontal pole

F4 = right frontal

F8 = right fronto-temporal

C4 = right central

T4 = right temporal

P4 = right parietal

T6 = right postero-temporal

O2 = right occipital

A2 = reference to right ear

G = ground

Fz = mid frontal

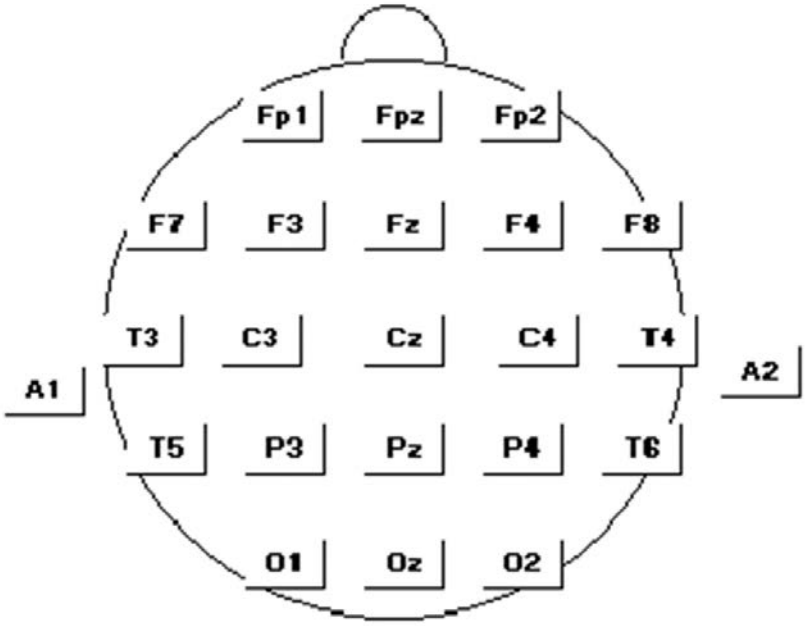
Cz = midline

Pz = mid posterior

EEG Electrodes

- The letter refers to the area of brain underlying the electrode, e.g.
  - **F - Frontal lobe,**
  - **T - Temporal lobe,**
  - **C- Central,**
  - **P- Parietal,**
  - **O- Occipital,**

Even numbers: right side of the head.
Odd numbers: left side of the head.



Montage

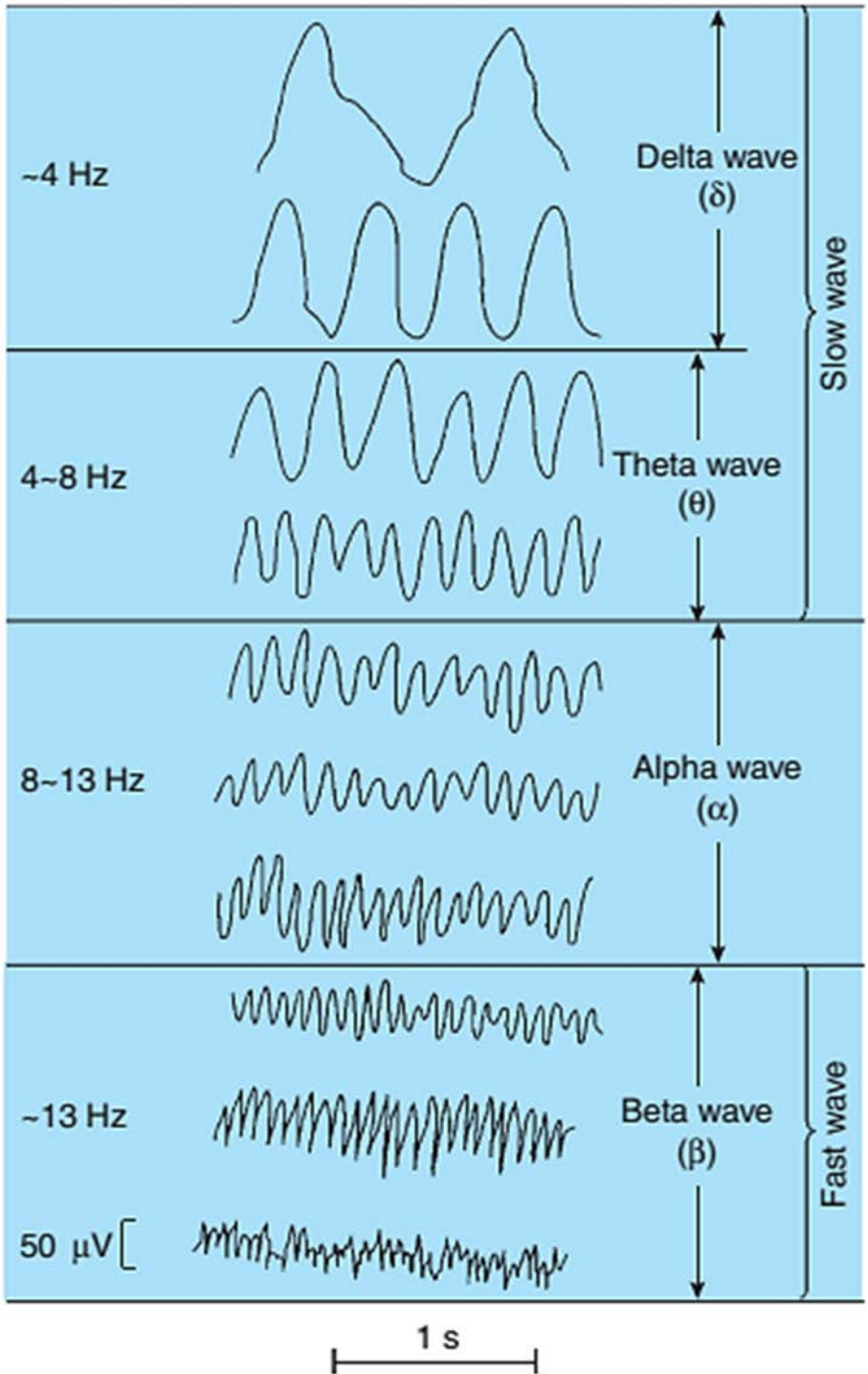
- Different sets of electrode arrangement on the scalp by **10 – 20 system is known** as **montage**.
- 21 electrodes are attached to give 8 or 16 channels recording.

Two types of recordings

- **Bipolar** – both the electrodes are at active site
- **Unipolar** – one electrode is active and the other is indifferent kept at ear lobule or mastoid process.

Normal EEG Waves

Frequency (Hz)	Type of EEG wave
1–4	Delta (δ)
4–7	Theta (θ)
8–13	Alpha (α)
14–30	Beta (β)



Alpha wave (Berger Rhythm)

8-13 Hz , amplitude 50µV

- **Rhythmical waves** occurring in almost all **healthy adults** in **relaxed** and **awake state** with **eyes closed**
- mostly on **occipital lobe,**
- **Disappear during sleep**
- **Frequency decreases** in **hypoglycemia, hypothermia, hypercapnia and hypocortisolemia**

Alpha block (alpha attenuation)

- is a phenomenon in which α wave attenuates and are replaced by the **fast**, **irregular** waves of **low amplitude**.

- *Alpha block occurs when*:

1. **Eyes open**,
2. **Conscious mental activity**, such as doing **mathematical calculations** and When any form of **stimulation** is applied

- The term ***aroused*** or ***alerting response*** is also used to denote α block.

Mu Rhythms

- In addition to the alpha rhythms of the visual cortex (area 18), rhythmic activities with about the same frequency range (8–13 Hz) have been shown to occur in other cortical areas, namely in the somatosensory cortex (areas 1, 2 and 3).

- These activities are known as "**rolandic mu rhythms**", or "**wicket rhythms**" , and have a typical reactivity, since they appear when the subject is at rest and are blocked by movement.

Beta wave

irregular, 14-30 Hz, 5-20 µV

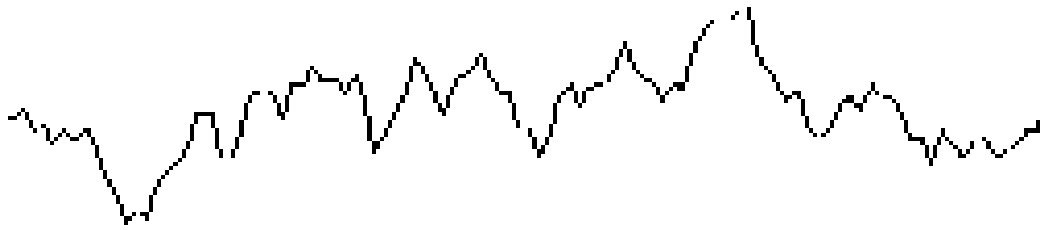
- mostly on **parietal** and **frontal** region

Seen in:

i. **mental activity** or **excitement**
ii. **Arousal** response (or **α block**),
iii. **Barbiturates**,
iv. **Infants** have fast β-like activity in EEG

Theta wave

4-7 Hz, 50-100 µV



Seen in:

1. **parietal** and **temporal** region in **children**
2. **Emotional stress** in adults (**disappointment** & **frustration)**.
3. **Degenerative brain states**
4. 10-30% **normal adult** individuals in **alert state.**

Delta wave

Slow waves, < 3.5 Hz, 100-200 µV

Seen in:

1. very **deep sleep,**
2. **Infancy,**
3. **Serious organic brain disease,**

- *Represents a highly synchronous inherent activity of cortical neurons independent of thalamic inputs.*

- ***Gamma rhythms:*** fast, 30–90 Hz, and signal an activated or attentive cortex.

- **Additional rhythms:**
  - ***spindles***, brief 8–14 Hz waves in sleep,
  - ***ripples***, brief bouts of 80–200 Hz oscillations,

In general

- **High-frequency**, **low-amplitude** rhythms: are associated with
  - **alertness** and **waking**, or
  - **dreaming stages** **of sleep**.

- **Low-frequency**, **high-amplitude** rhythms: are associated with
  - **non-dreaming** **sleep states**,
  - certain **drugged states**, or
  - pathological condition or **coma**

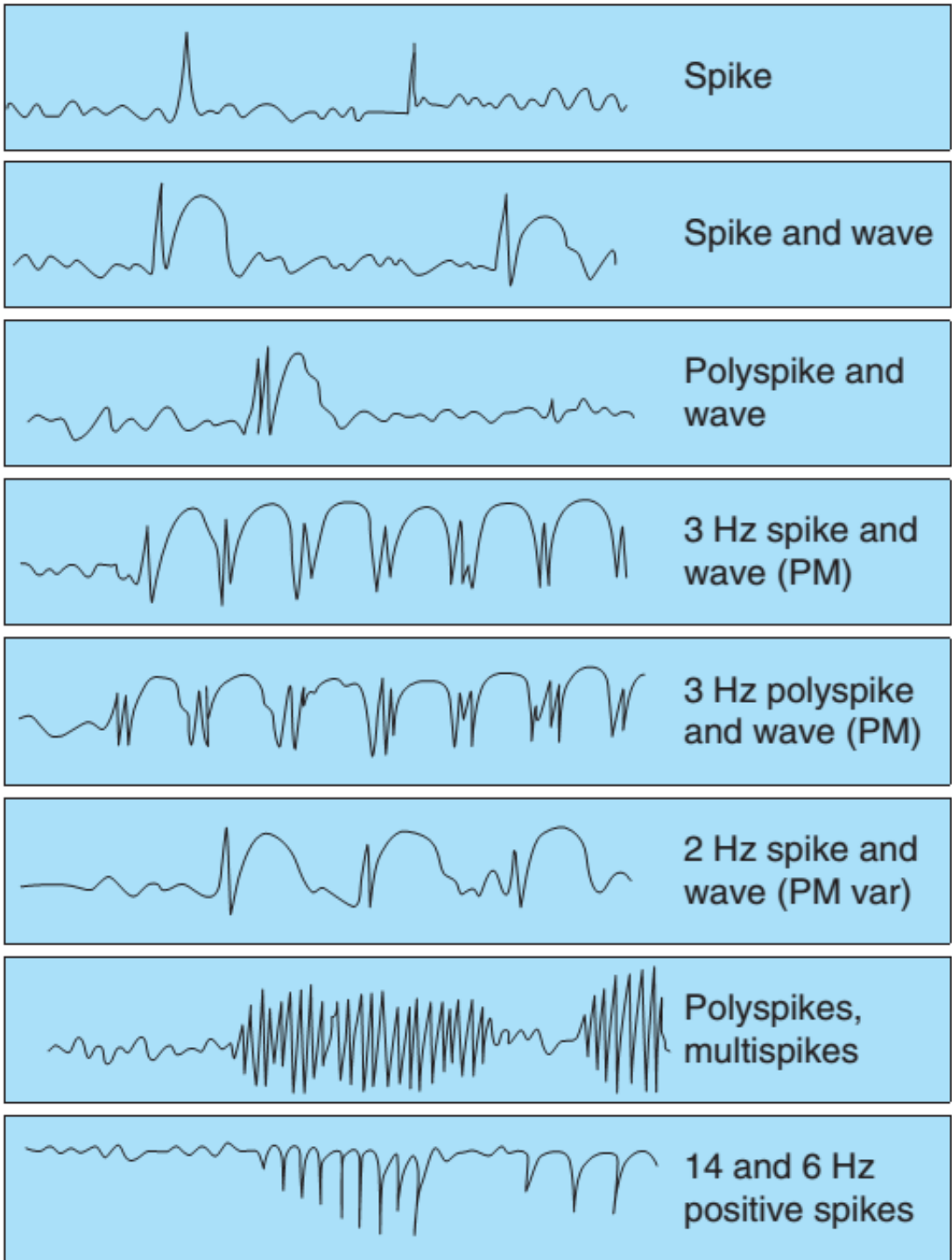
ABNORMAL EEG WAVEFORMS

- **Epilepsy**
- **Sleep disorders** (Polysomnography)
    - Narcolepsy
    - Sleep apnea syndrome
    - Insomnia and parasomnia
- **Consciousness dysfunction**
    - coma
    - Syncope
    - Stupor
- **Brain death**
    - Flat EEG(absence of electrical activity) on two records run 24 hrs apart.
- **Organic brain dysfunction**

Epileptiform EEG discharges

- In general, epileptiform wave may be

1. A **spike** (duration of 20-70 ms)
2. A **sharp** wave (duration of 70-200 ms)
3. A **spike and wave complex**



Types of EEG test

- Routine EEG,
- Some specialized types
  - *Strobe lighting,*
  - *Sleep EEG,*
  - *Sleep-deprived EEG,*
  - *Ambulatory EEG,*
  - *Video-telemetry,*

Provocation test

- As EEG is recorded during interictal period, artificial triggering of epileptiform waves can be done by:

1. **Intermittent photic stimulation** (flashes of bright light having frequency of 1-30/s) done for 10 seconds
    - Increase rate & decrease amplitude

2. **Hyperventilation** for 3-5 minutes
    - Decrease rate & increase in amplitude

Are there any risks or side effects?

- The EEG procedure is **painless**, **comfortable** and generally **very safe**.
- Patient may **feel lightheaded** and notice a **tingling** in lips and fingers for a few minutes during the **hyperventilation** part of the test.
- There's a very small risk of seizure while the **provocation test** is carried out, but you'll be closely monitored and help will be on hand in case this happens.

Seizures and Epilepsy

- **Seizures** are temporary disruptions of brain function caused by **uncontrolled excessive neuronal activity**.

- **Epilepsy** is a chronic condition of recurrent seizures that can also vary from brief and nearly undetectable symptoms to periods of vigorous shaking and convulsions

- ***The International League against Epilepsy (ILAE) Commission on Classification and Terminology, 2005–2009*** has provided an updated approach to classification of seizures, based on the clinical features of seizures and associated EEG findings

CLASSIFICATION OF SEIZURES

1. **Focal seizures**

   (Can be further described as having motor, sensory, autonomic, cognitive, or other features)

2. **Generalized seizures**

   a. Absence

      Typical

      Atypical

   b. Tonic clonic

   c. Clonic

   d. Tonic

   e. Atonic

   f. Myoclonic

3. **May be focal, generalized, or unclear**

   Epileptic spasms

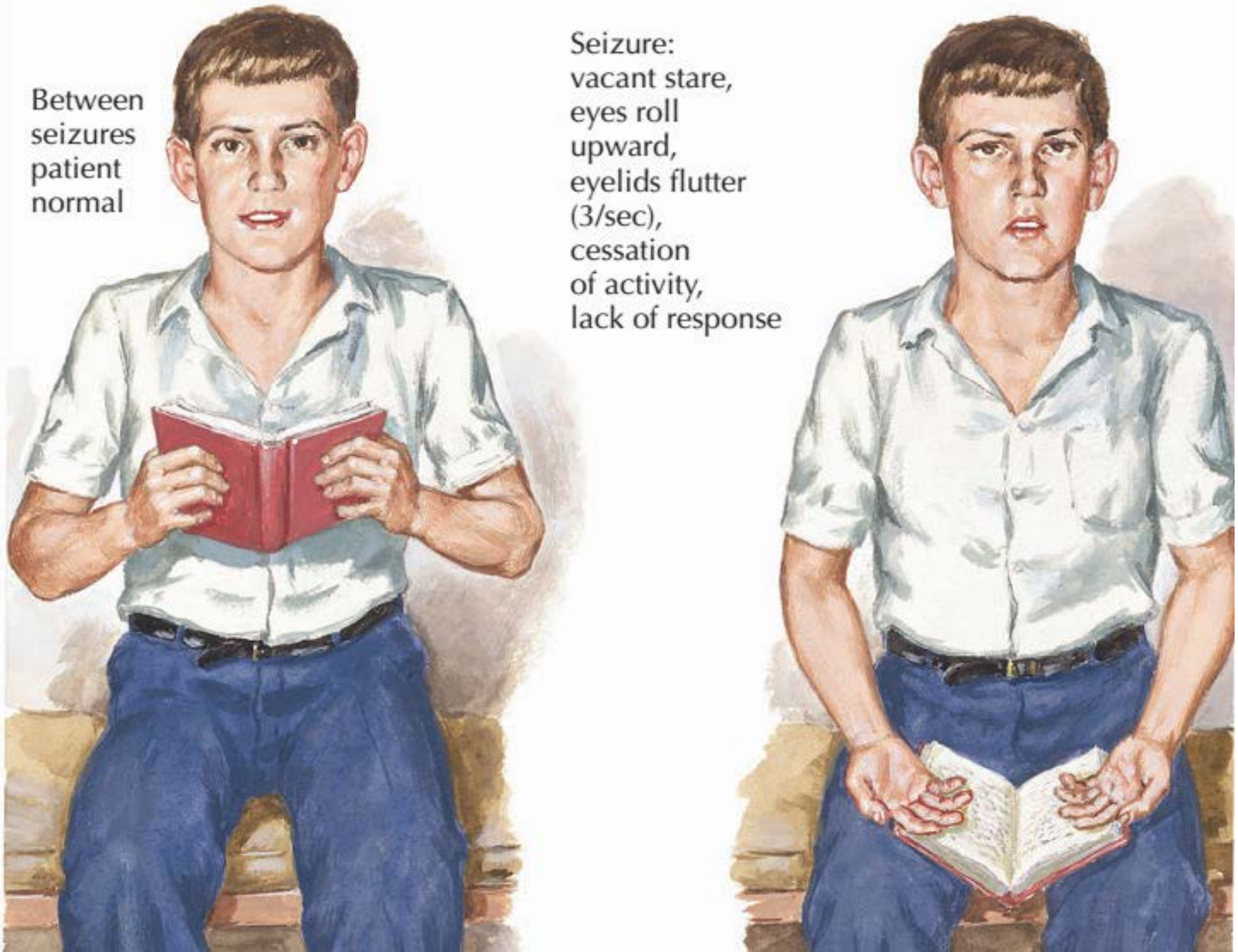
Generalised epilepsy

- **Typical Absence seizures (Previously known as Petit Mal seizures)**

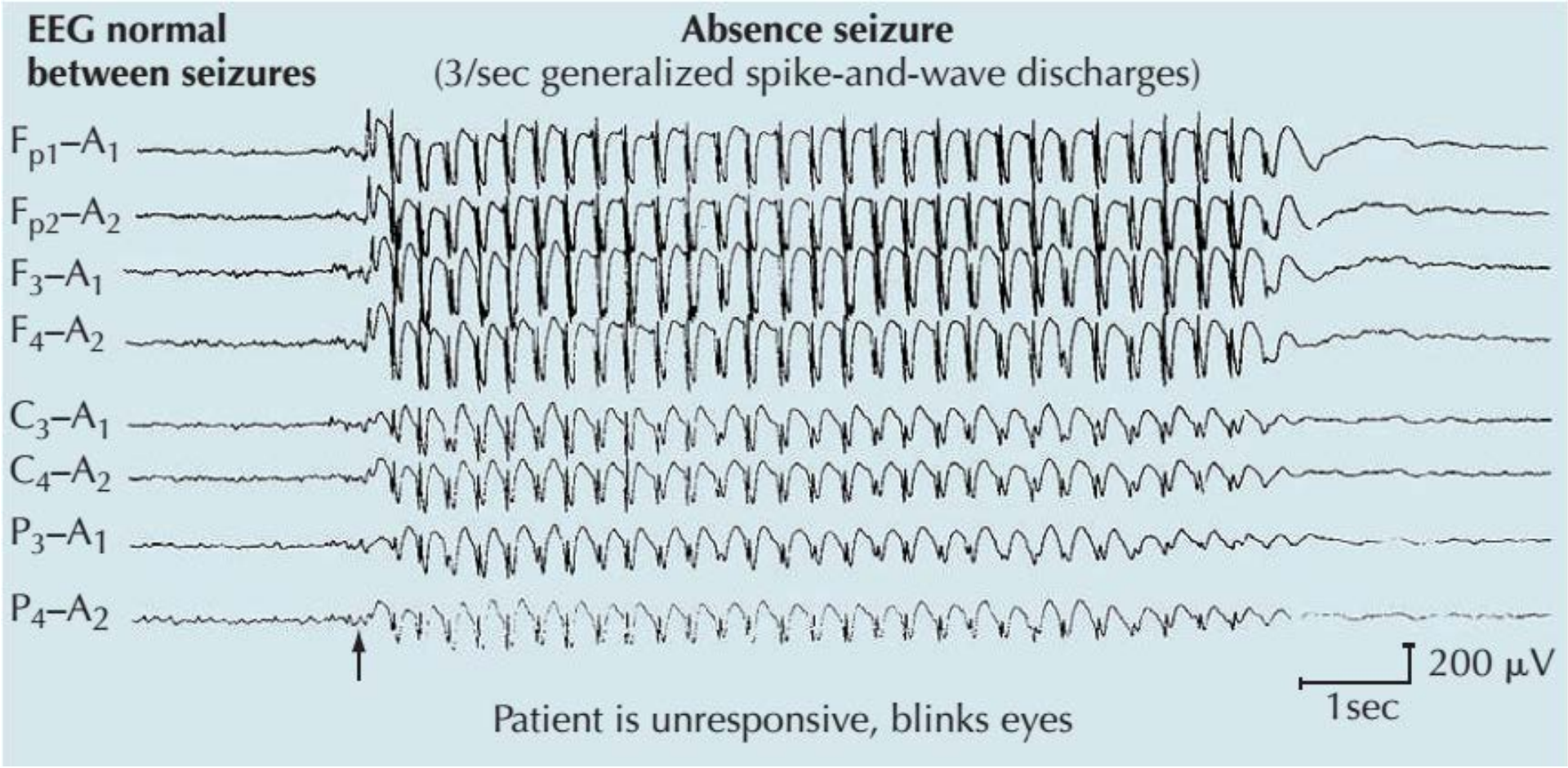
➢ The EEG hallmark of typical absence seizures is a **generalized**, **symmetric**, 3-Hz **spike-and-wave** discharge that **begins and ends suddenly**, superimposed on a normal EEG background.

- Atypical Absence Seizure

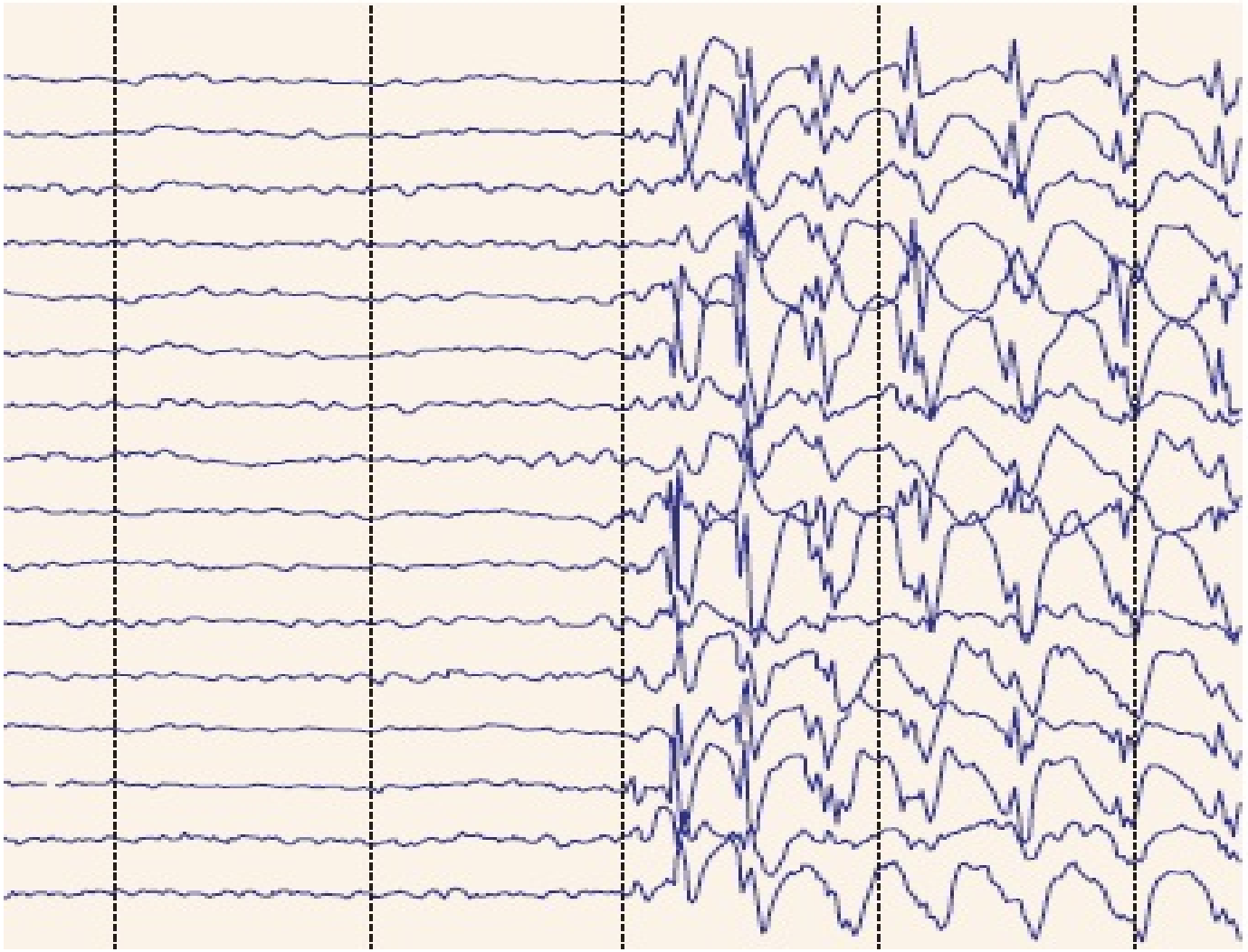
➢ The EEG shows a **generalized**, **slow spike-and wave** pattern with a frequency of ≤2.5 per second, **as well as other abnormal activity**


Between seizures patient normal
Seizure: vacant stare, eyes roll upward, eyelids flutter (3/sec), cessation of activity, lack of response

Absence seizure



Generalised epileptic discharge, as seen in epilepsy syndromes such as juvenile myoclonic epilepsy.



Generalised tonic clonic seizure (previously known as grand mal seizure)

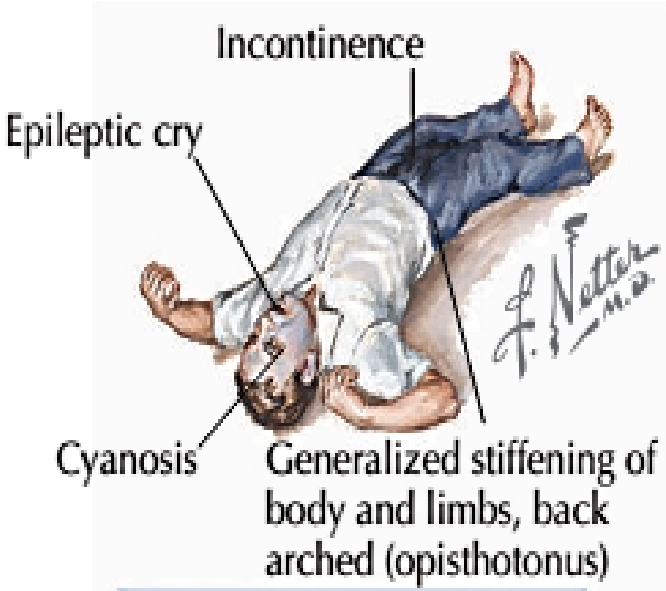
- **In EEG**

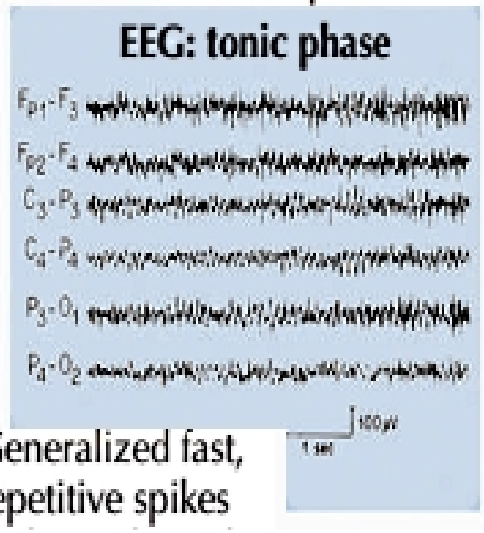
➢ **Tonic phase** of the seizure shows a progressive increase in **generalized low-voltage fast activity**, followed by **generalized high-amplitude**, **polyspike discharges**.

➢ **Clonic phase**, the **high-amplitude** activity is typically interrupted by slow waves to create a **spike-and-wave pattern**.

➢ **Postictal** EEG shows **diffuse slowing** that gradually recovers as the patient awakens.

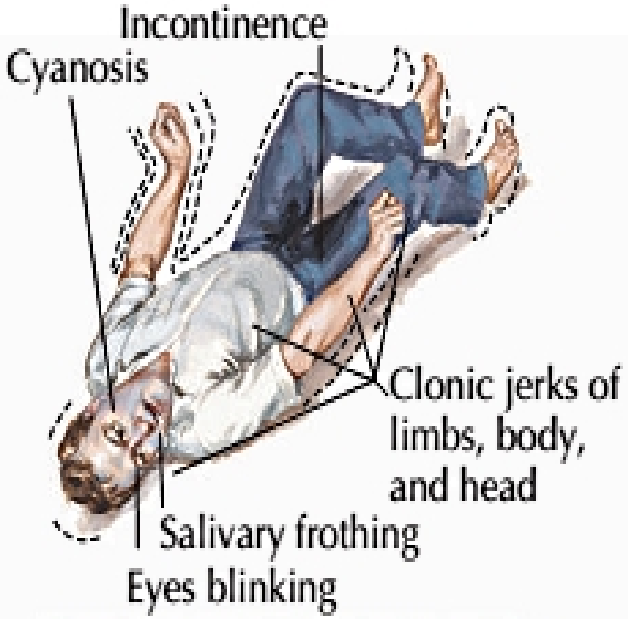
A. Tonic phase

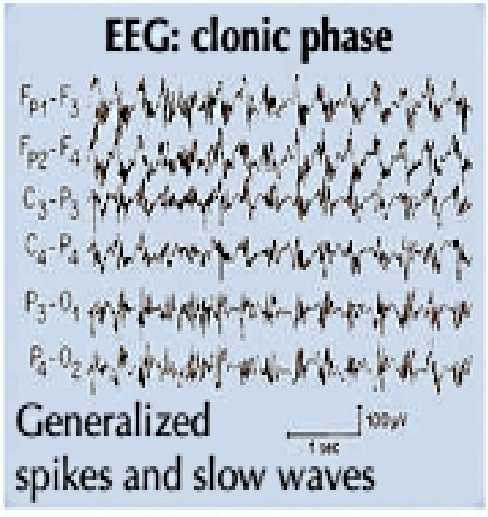




Generalized fast, repetitive spikes

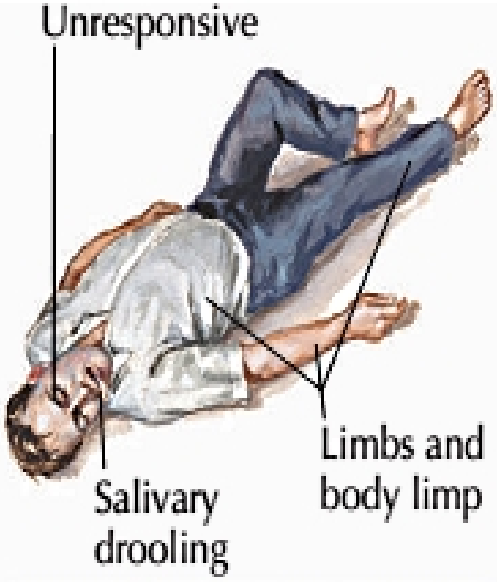
B. Clonic phase

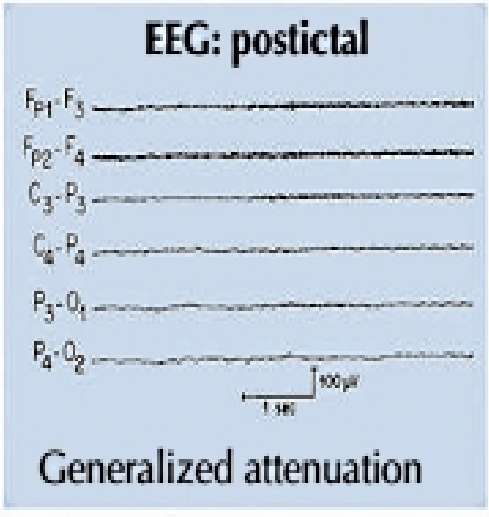




Generalized spikes and slow waves

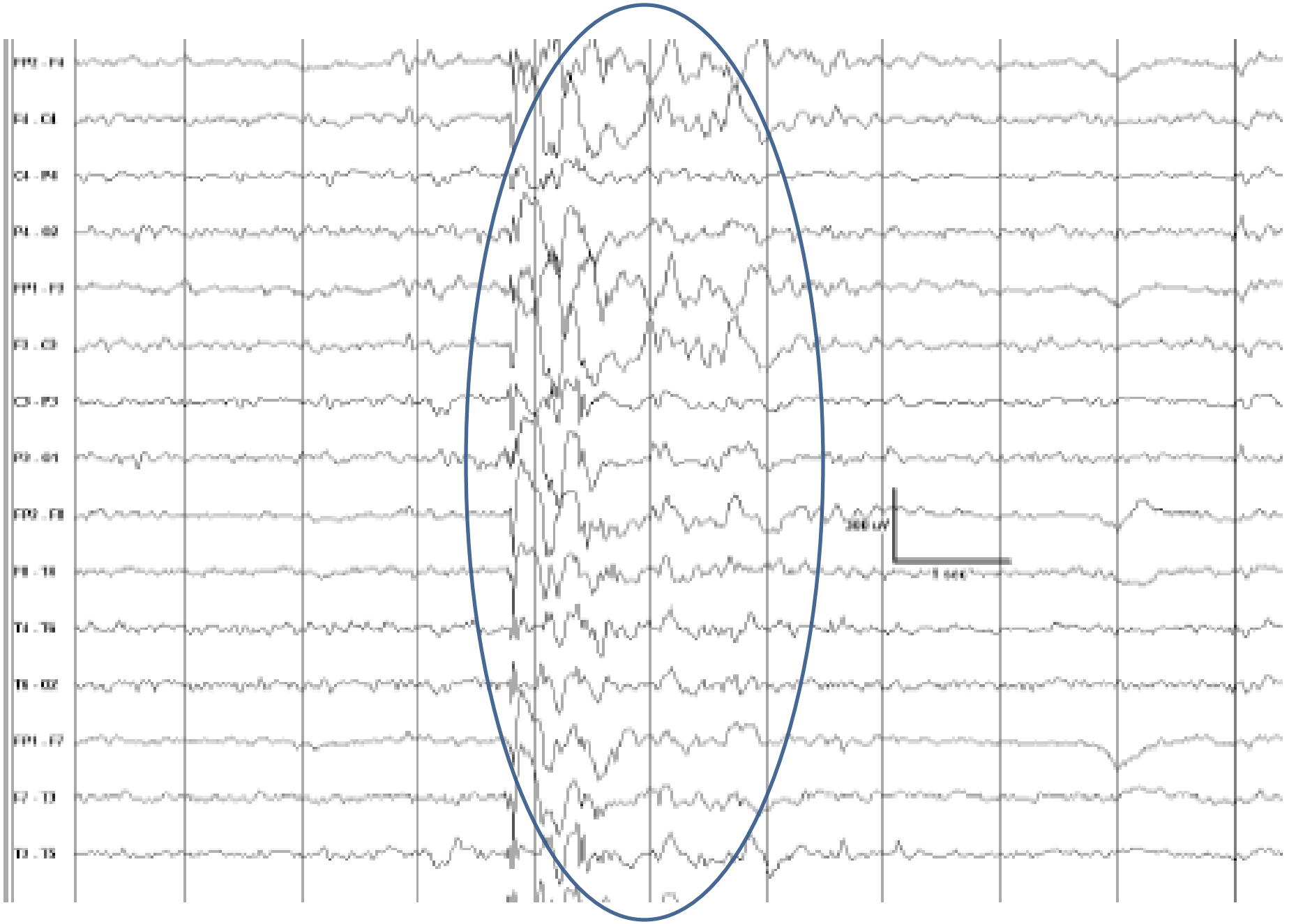
C. Postictal stupor





Generalized attenuation

Generalized polyspike and waves in Juvenile Myoclonic Epilepsy



FOCAL SEIZURES

- Focal seizures arise from a neuronal network either discretely localized within one cerebral hemisphere or more broadly distributed but still within the hemisphere.

- focal epilepsy results from **some localized organic lesion** or **functional abnormality**, such as

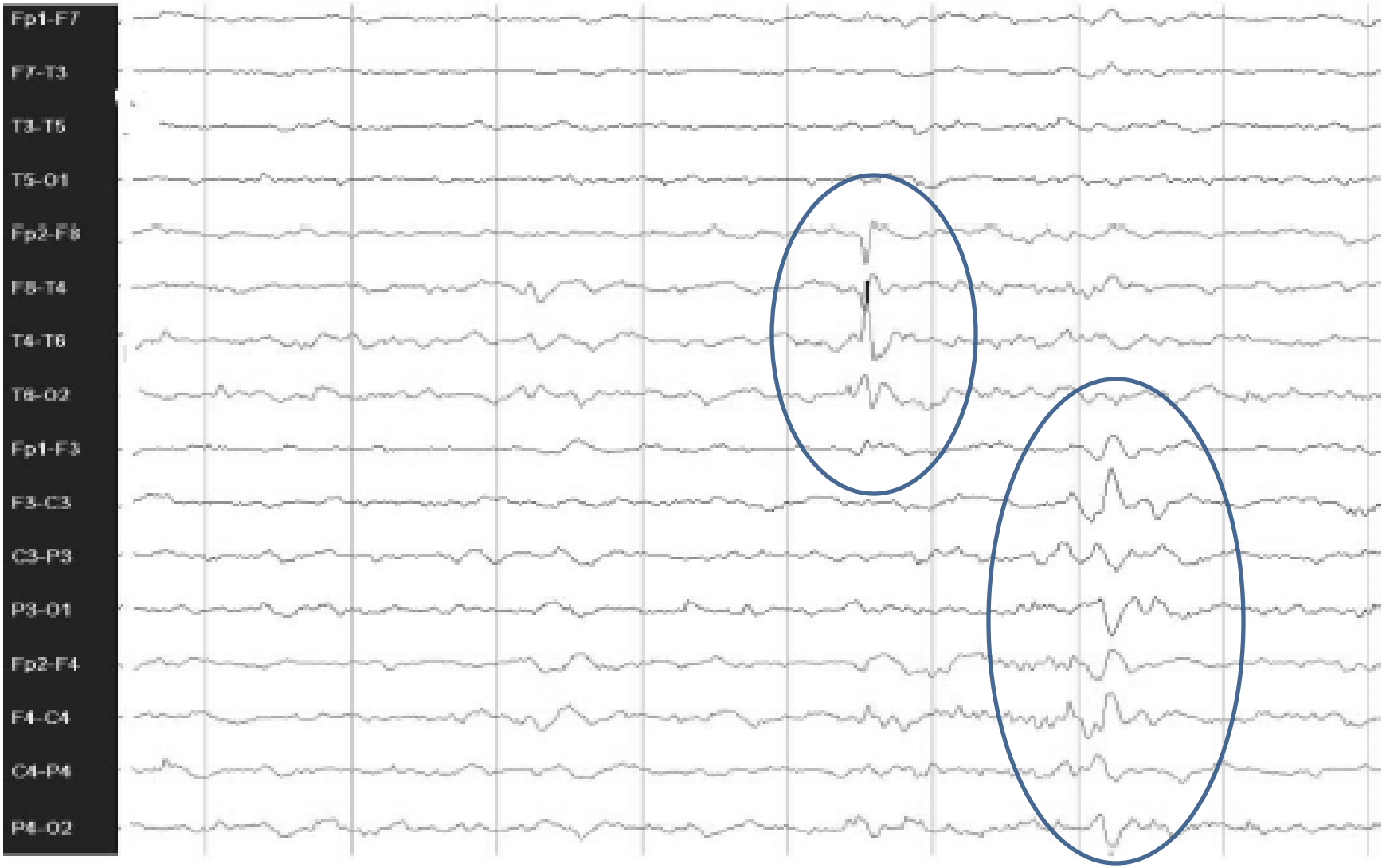
1. **scar tissue** in the brain,
2. a **tumor** that compresses an area of the brain,
3. a **destroyed area** of brain tissue, or
4. **congenitally deranged** local circuitry.

- With the new classification system, the subcategories of “**simple focal seizures**” and “**complex focal seizures**” have been eliminated.

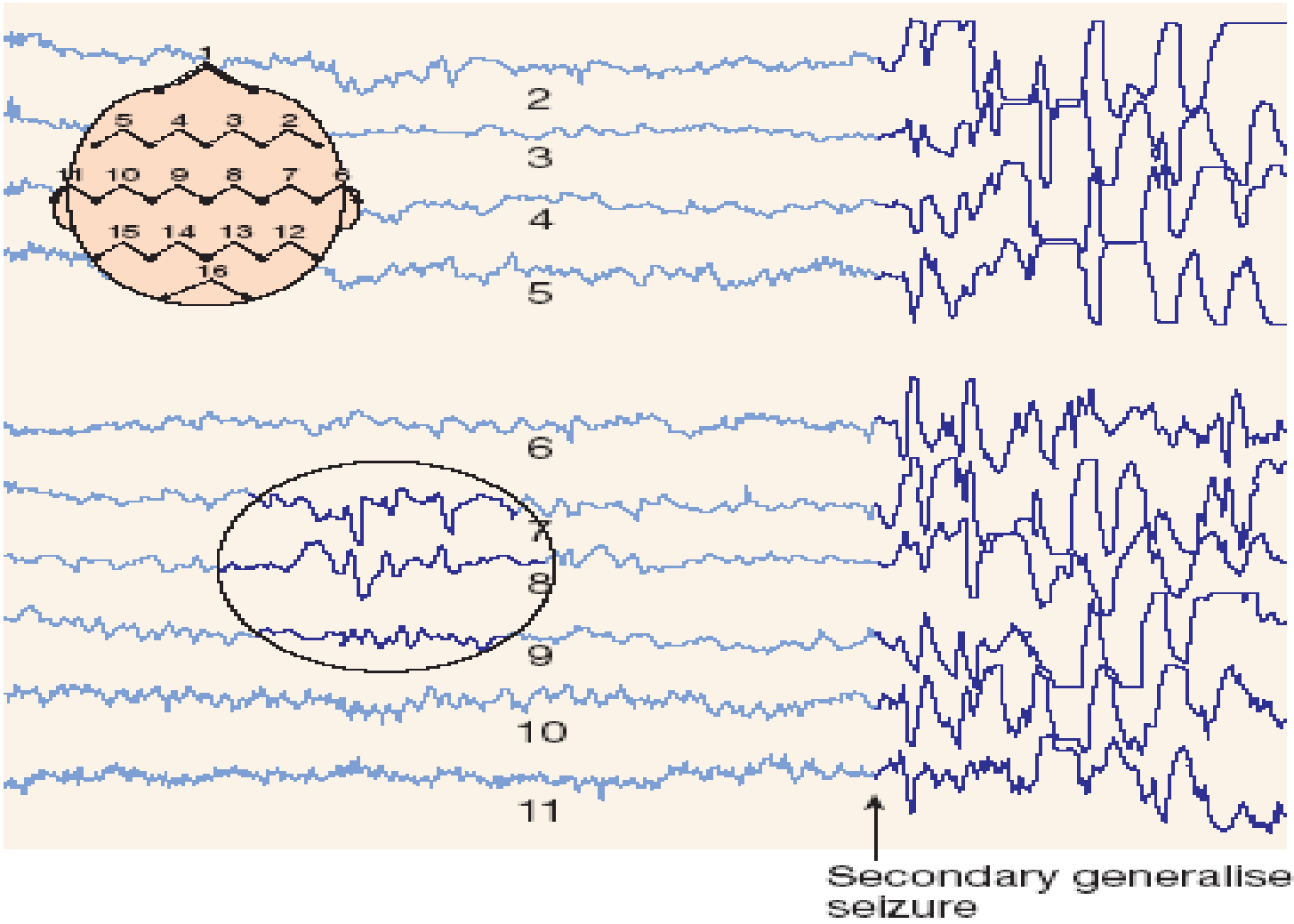
- Instead, depending on the presence of **cognitive impairment**, they can be described as ***focal seizures with or without dyscognitive features.***

- **Focal seizures with secondary generalization** has been renamed to ***evolution of focal seizures to generalized seizures.***

Complex partial seizure (focal epilepsy)

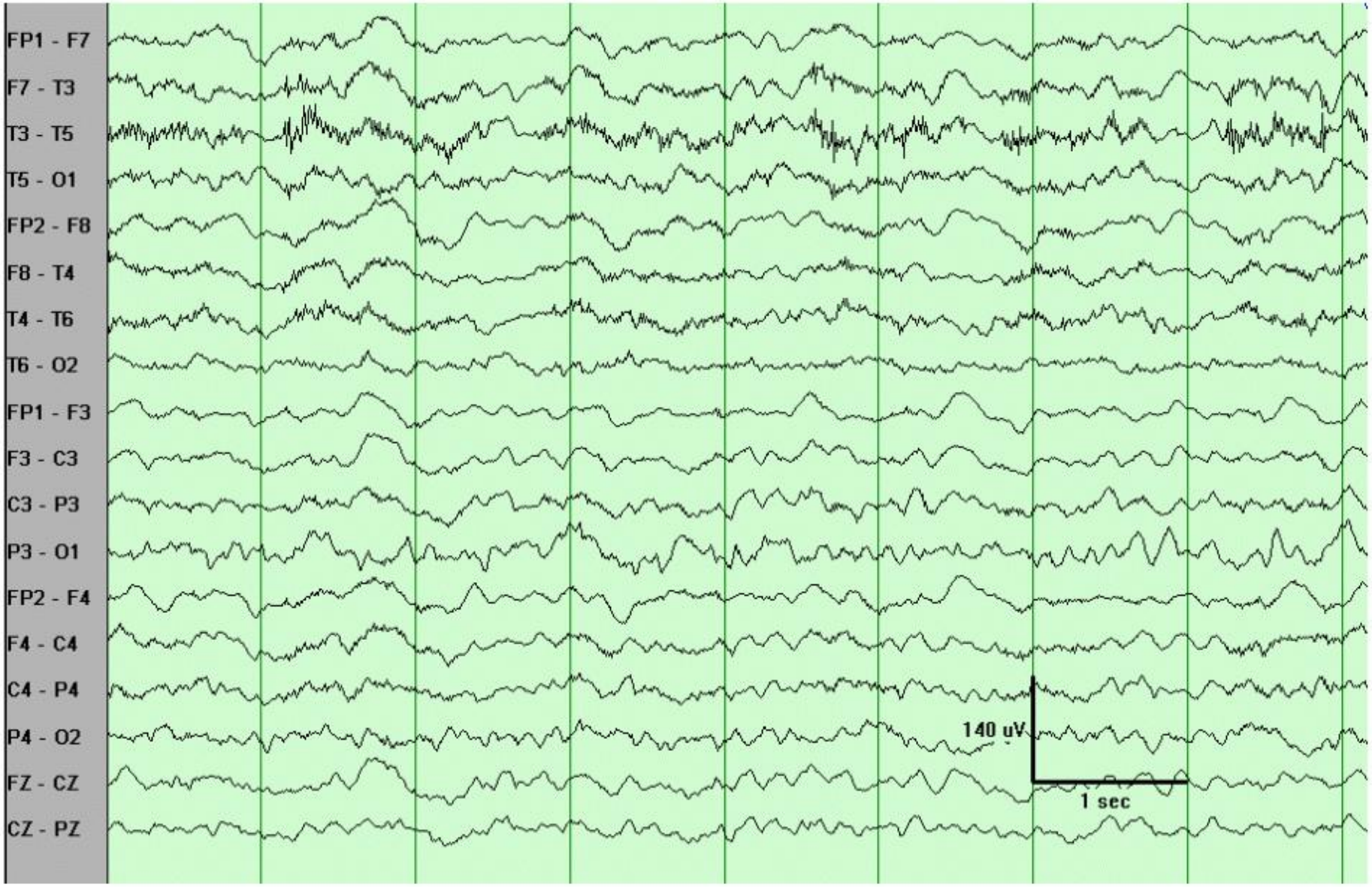


Focal sharp waves over the right parietal region (circled), with spread of discharge to cause a generalised tonic–clonic seizure.



Hepatic encephalopathy

Classification: Background slow. The posterior dominant background (alpha rhythm) is at 7 Hz (slower than the alpha frequency range). There is no other generalized slow activity. Since this patient is older than 8 years, and the patient is clearly awake, this is abnormal. This represents (electrographically) the mildest degree of diffuse encephalopathy.



Classification: Continuous slow, generalized. While there are some faster frequencies, this sample is dominated by generalized polymorphic delta activity. If this is "continuous" (greater than 80% of the recording), this usually goes along with a severe diffuse encephalopathy.

Limitation of the EEG (sensitivity)

- **Some abnormal activity may not be detected where:**
  - The area is too small on the brain's surface
    - Need 4 cmm^2 surface area of cortex to be involved.
  - Foci located too deep in the brain
    - Mesial aspect & inferior aspect of cortex.
  - Limited time sampling,
- **Poor technical quality.**

Limitation of the EEG (specificity)

- **Some non-specific EEG abnormalities in normal person** (up to 10%).
- **Paroxysmal epileptiform activity** in the absence of any clinical seizures (1% of people with migraine, stroke)
- **Benign focal epileptiform discharges in children without seizures** (2-4%).

- ***so, a normal result does not rule out epilepsy,***

and

- ***an abnormal result does not necessarily mean that patient have epilepsy.***

Conclusion

- EEG is a very powerful electrobiological imaging tool in the field of medicine, neurology, clinical neurophysiology.
- All clinicians should have some knowledge regarding this very useful test.

References

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Thank you