Use Of Electroencephalography (EEG) In The Management Of Seizure Disorders

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Electroencephalography

- 1st used in humans by Hans Berger in 1924 (the first report was published in 1929)
- A tracing of voltage fluctuations versus time recorded from electrodes placed over scalp in a specific array
- Represent fluctuating dendritic potentials from superficial cortical layers
- Required amplification
- Deep parts of the brain are not well sampled

Types of EEG Recording

- Routine
  - analog, digital
  - with computerized analysis & brain electrical activity mapping
- Long-term Monitoring
**Routine EEG Techniques**

- 20-min or longer sampling of brain activity
- Written out or recorded directly on magnetic tape or digitally by computer
- Disc electrodes are applied according to 10-20 system of electrode placement
- Montages: referential, bipolar, changeable with digital recording

**10-20 System Of Electrode Placement**

- Established in 1958
- Electrodes are spaced at 10% or 20% of distances between specified anatomic landmarks
- Use 21 electrodes, but others can be added
  - increase spatial resolution
  - record from specific areas
  - monitor other electrical activity (e.g. ECG, eye movements)
- Odd number electrodes over left and even number over right hemisphere

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10-10 System Of Electrode Placement

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### Longitudinal Bipolar Montages

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<th>Channel No.</th>
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### Transverse Bipolar Montages

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Activations

- **Routine**
  - Eye opening and closure
  - Hyperventilation
  - Intermittent photic stimulation
    - 1, 5, 10, 15 & 20 Hz
    - eyes open
    - eyes closed
    - eyes closure

- **Optional**
  - Sleep deprivation
  - Sedated sleep
  - Specific methods of seizure precipitation
    - video games
    - visual patterns
    - AED withdrawal

Strength and Advantages of EEG

- Is a measure of brain function; supplement neuroimaging studies
- Provides direct rather than indirect evidence of epileptic abnormality
- May be the only test that shows abnormalities in epileptic patients
- Provides some spatial or localization information
- Low cost
- Low morbidity
- Readily repeatable
- Portable / ambulatory

Limitations and Disadvantages Of EEG

- Detects cortical dysfunction but rarely discloses its etiology
- Relatively low sensitivity and specificity
- Subject to both electrical and physiologic artifacts
- Influenced by state of alertness, hypoglycaemia, drugs
- Small or deep lesions might not produce an EEG abnormality
- Limited time sampling (for routine EEG) and spatial sampling
- May falsely localize epileptogenic zone
Uses Of EEG In The Management of Seizure Disorders

- To support a clinical diagnosis of epilepsy
- To help to classify seizures
- To help localize epileptogenic focus, especially in presurgical candidates
- To quantify seizures
- To aid in the decision of whether to stop AED treatment
- Not a good guide to the effectiveness of treatment, except in absence seizures

Analyzing EEG Activities

- Morphology
- Distribution
- Frequency
- Voltage
- Duration
- State of the patient
- Background from which activity is arising from
- Similarity or dissimilarity to the other ongoing background rhythms

Guidelines To EEG Interpretation

- Each EEG should be read with maximum possible objectivity
- Ideally an EEG'er should describe the findings and make an EEG diagnosis without knowledge of the patient's history
- Clinical significance of the findings can then be judged by integrating the EEG diagnosis with the history

EEG Interpretation

- Normal
  - Lack of Abnormality
- Abnormal
  - Non-epileptiform Patterns
  - Epileptiform Patterns
Epileptiform Patterns on Scalp-recorded EEG

- Interictal Epileptiform Pattern
- Electrographic Seizure Pattern
  - Isomorphic seizure pattern
  - Metamorphic seizure pattern

Criteria For Potentially Epileptogenic Transients

- Clearly of cerebral and not artifactual origin
- Abnormal for the age and the state of the patient
- Have a significant epileptiform character and not one of the benign epileptiform variants

Physiologic Activities That Can Be Confused With Epileptiform Activities

- Vertex transients of light sleep
- Hypnagogic hypersynchrony
- Positive occipital sharp transients of sleep (POST)
- Mu rhythm
- Lambda waves
- Breach rhythms
Benign Variants Of Unknown Clinical Significance

- Benign epileptiform transients of sleep (small sharp spikes)
- 6- and 14-Hz positive spikes
- Wicket spikes
- Psychomotor variants (rhythmic mid-temporal theta discharge of drowsiness)
- Subclinical rhythmic EEG discharge of adults
- Phantom spike and wave
Examples Of Inter-ictal Epileptiform Patterns

- Spikes
- Sharp waves
- Benign Epileptiform Discharges of Childhood
- Spike-and-wave complexes
- 3Hz Spike-and-wave complexes
- Slow spike-and-wave complexes
- Hypsarrhythmia
- Photo-paroxysmal response

Interictal Spikes / Sharp Waves

- Spikes (<70 msec in duration) or Sharp Waves (70-200 msec in duration)
- Usually surface negative; occasionally bipolar or only surface positive
- Monophasic, biphasic or polyphasic
- Occur alone or accompanied by an after-coming slow wave (usually surface negative and higher in amplitude than the spike or sharp wave)
- Occurs singly or in burst, lasting at most a few seconds
- Focal or generalized
- No clinical manifestation

Inter-ictal Epileptiform Patterns

- Idiopathic Epilepsies
  - Generalized
    - 3 Hz spike-and-wave
    - Polyspikes
    - Atypical spike-and-wave
  - Partial / Focal
    - Benign focal epilepsy of childhood with centotemporal spikes
    - Benign focal epilepsy of childhood with occipital spikes
- Symptomatic Epilepsies
  - Generalized
    - Hypsarrhythmia
    - Slow spike-and-wave
    - Paroxysmal fast activity
    - Multiple independent spike foci
  - Partial / Focal
    - Temporal
    - Frontal
    - Centro-parietal
    - Occipital
    - Midline
Hypsarrhythmia

Slow Spike & Wave Complexes

Fp1 – F7
F7 – T3
T3 – T5
T5 – O1
Fp2 – F8
F8 – T4
T4 – T6
T6 – O2
Fp1 – F3
F3 – C3
C3 – P3
P3 – O1
Fp2 – F4
F4 – C4
C4 – P4
P4 – O2
Fz – Cz
Cz – Pz
T1 – T2
A1 – A2

EKG

Photic

Benign Epileptiform Discharges of Childhood

Focal Inter-ictal Epileptiform Pattern

- Temporal, frontal, occipital, centroparietal, centrotemporal, or midline
- Relative frequency (Gibbs and Gibbs, 1952)
  - 1396 patients; Temporal: 73%; Frontal: 0.8%
- Likelihood of seizures (Kellaway, 3526 children)
  - Temporal: 90-95% (91%)
  - Frontal: 70-80% (75%)
  - Parieto-occipital: 40-50% (48%)
  - Central: 30-40% (38%)
- Focal spikes in a patient with a history of epileptic seizures indicates that the patient is likely to have focal or localization-related epilepsy syndrome
Epileptiform Activity In People Without Epilepsy

- Zivin and Ajmone-Marsan, 1980
  - 142/6497 (2.2%) of non-epileptic patients had IEDs
  - only 20/142 (14.1%) eventually developed epilepsy

- Eeg-Olofsson et al, 1971
  - 2.7% and 8.7% of 743 normal children had IEDs during wakefulness and sleep, respectively

- Cavazutti et al, 1980
  - 131/3726 children (3.5%) had IEDs on awake EEG
  - only 7/131 (5%) eventually developed seizures

Presence of interictal epileptiform discharges (IEDs) is not diagnostic of epilepsy

Normal EEG In People With Epilepsy

- I know my patient has epilepsy. How can the EEG be normal?
- If the EEG is normal, am I wrong in thinking that my patient has epilepsy?

- Ajmone-Marsan & Zivin, 1970
  - only 56% of 1824 EEGs from 308 patients (1-64 years) with known seizures showed IEDs on first EEG
  - IEDs recorded in another 26% in subsequent records

- Holmes, 1986
  - 25% of 24 pediatric patients with documented seizures on long-term monitoring had no IEDs
  - first and only EEG abnormalities recorded was complex partial seizures

  Patients with well-documented seizures may have normal EEGs

Factors Responsible For Detection Of Epileptiform Discharges

- Characteristic of Generator Source
  - Voltage of cortical discharge which is directly related to size/area of cortex involved in generation of synchronous activity

- Distance between electrodes and the generator source

- Orientation of dipole

- Sampling Time

- Activation
Factors Which Modify Spike Frequency

- Sleep
- Photic stimulation
- Hyperventilation
- Temporal relation to a seizure
- Age of patient
- Effect of anticonvulsant withdrawal

Recording of Focal Interictal Spikes

- Yield of recording focal interictal spikes increases
  - during NREM sleep, especially stage 3/4
  - after sleep deprivation
  - after seizures
  - during long-term monitoring
  - ? using supplementary electrodes (e.g. sphenoidal)
- Occurrence of focal interictal spikes is not affected
  - by increasing or decreasing the AED dosages or level
  - by hyperventilation or photic stimulation
  - before seizures

Does the Frequency of IEDs Tell Us Anything?

- Probably not
- Increases after a seizure
- Does not predict severity of epilepsy
- Relationship between spikes and ictal activity is not known

Routine EEG

Concluding Remarks

- EEG is the most valuable tool in the evaluation of patients with a seizure disorder
- Interpretation of clinical significance of EEG abnormality(ies) can only be made by a physician who
  - is evaluating the patient’s history and physical findings
  - has an understanding of the benefits and limitations of EEG recording
Epileptiform Patterns on Scalp-recorded EEG

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- Electrographic Seizure Pattern
  - Isomorphic seizure pattern
  - Metamorphic seizure pattern

Electrographic Seizure Pattern

- Rhythmic repetition of components that may or may not have an epileptiform morphology
- Lasting more than several seconds
- When this pattern produce clinical symptoms and/or signs, it is called a clinical electrographic seizure discharge
- When it does not produce clinical symptoms, it is called a subclinical electrographic seizure discharge

Isomorphic Seizure Pattern

- Ends as it begins, without progressing through multiple phases into a postictal phase
- Ictal morphology is usually similar to interictal epileptiform patterns
- Differ only in having greater rhythmicity, duration, spatial extent and amplitude
- Almost exclusively seen in generalized seizures
- Prototype: 3/s spike-and-wave complexes

Metamorphic Seizure Pattern

- Ends differently from its beginning, commonly progressing through 2 or more different ictal phases into a postictal state
- Ictal morphology can also be dissimilar to interictal epileptiform patterns
- Ictal morphology may consist of smooth sinusoidal rhythms and has no spike or sharp wave
- Seen both in generalized seizures and focal seizures
ICTAL EEG

- Always abnormal in generalized seizures
- Almost invariably abnormal during a partial seizures especially with loss of consciousness
- Might be normal for simple partial seizures
- Should be correlated with behavioral changes

Long-term EEG Monitoring

- In- or out-patient setting
- Methods
  - Prolonged Conventional
  - Ambulatory
  - With video recording of behavior
    - analog, digital
  - Telemetered EEG recording
    - radio, cable
Video/EEG Monitoring

- To obtain a prolonged interictal EEG sample
- To record habitual seizures or spells
- To make precise EEG / behavioral correlation
- To classify seizures (e.g. absence vs. complex partial)
- To localize epileptogenic focus, especially in epilepsy surgery candidates
- To quantify seizures when they occur frequently
- Evaluate seizure precipitants

Questions To Be Answered After Video/EEG Monitoring

- Does the patient have epilepsy?
- Where do the seizures come from?
- Is the patient a candidate for surgical treatment?