EEG Misreads / EEG Barriers

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John Stern, MD
Geffen School of Medicine at UCLA
Los Angeles, CA
## Disclosure

<table>
<thead>
<tr>
<th>Name of Commercial Interest</th>
<th>Type of Financial Relationship</th>
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Learning Objectives

- EEG should be interpreted in its clinical context.

- EEG’s limitations should be considered in its interpretation.

- Diagnostic errors can arise when unexpected EEG results are not questioned.
Background

• EEG is a critical test for epilepsy diagnosis.
  – Can distinguish epilepsy from other diagnoses.
  – Can distinguish focal from generalized.

• EEG is a critical test in epilepsy surgery evaluation.
  – Can distinguish focal from multifocal.
  – Can localize the focus.

• EEG can fail in each of its critical functions due to interpreter error or its intrinsic limitations.
Three EEG Misreads

- Non-epileptic seizure appearing as epileptic seizure.
- Epileptic seizure appearing as non-epileptic seizure.
- Focal seizure appearing as generalized seizure.
43 year old man with episodes of dizziness and confusion for 1 year and "passing out" for 3 months.

Confusion accompanied by picking automatisms and lip smacking.

"Passing out" with tonic extension and falling.

Partial response to AED treatment. Several episodes occur weekly.

MRI: normal.
False Positive
False Positive: Lessons

• Evolving, rhythmic EEG activity can be artifact.
• Ictal EEG is interpreted best with accompanying video.
• Descriptions of ictal behavior cannot replace direct witnessing.
  – Witnesses are inaccurate for key behavioral features.

Syed, LaFrance, Kahriman, et al. (2011)
False Negative

- 46 year old man with mild-moderate mental retardation.
- Seizures for 44 years.
- Childhood seizures: motionless staring.
- Current seizures: anxiety followed by head drop and arm posturing or falling.
- Interictal EEG: bilateral, independent, temporal epileptiform discharges.
- MRI: normal.
False Negative
False Negative
False Negative

• Case series of 86 patients who had 394 seizures
  - All had intracranial video-EEG and subsequent resective surgery
• EEG “not helpful” for 49% of seizures
  - Recorded from 28% of patients
• No discernible epileptic EEG pattern for 22 of 225 complex partial seizures
  - Recorded from 4 patients, all frontal lobe onsets
• No discernible epileptic pattern for 4 of 77 secondarily generalized seizures
  - Recorded from 1 patient, parietal lobe onset

Lee, Kim, Hong, et al. (2000)
False Negative: Lessons

• Behavior that is stereotyped and consistent with epilepsy may be more informative than EEG.
• Stereotyped ictal EEG pattern may vary.
  – Record multiple seizures.
• Consider pre-test probability when deciding the duration of video-EEG monitoring.
Misinforming

- 17 year old girl diagnosed 8 years ago after GTC.
- “Space out” episodes for 9 years.
  - 10 sec of eye flutter and blank facial expression.
  - Sometimes turns to right.
  - Medication resistant.
- EEG: bifrontal spike and slow waves.
- MRI: normal.
- Diagnosis: generalized-onset seizures.
Misinforming
Misinforming: Lessons

- Small details within history and EEG may be critical.
- Reconsider diagnosis and repeat testing when questions arise.
- Secondary bilateral synchrony is useful in localization.
  - More likely frontal, less likely temporal.

Blume and Pillay (1985)
Three EEG Barriers

- Seizure diagnosis requires seizure occurrence.
- Interictal epileptiform discharges may falsely localize/lateralize epilepsy.
- Ictal onset zone may not be epileptogenic zone.
Seizure Occurrence

- 33 year old man with 1 year of unusual sleep disorder without diagnosis.
- Diagnoses: seizures, restless leg syndrome, sleep apnea, night terrors, somnambulism.
- Awakens agitated, sore, sometimes injured or having injured bed partner.
- 15 episodes have occurred.
- EEG: left temporal epileptiform discharges.
- MRI: normal.
Seizure Occurrence
Seizure Occurrence: Lessons

- Ictal EEG is more specific for epilepsy than interictal EEG.
- Indirect evidence can be useful and lead to a diagnosis.
- Success can be finding something that was not sought.
Interictal Misdirection

- 30 year old man with 16 year history of seizures.
- Seizures: speaks “gibberish,” unable to understand, amnestic. Has oral automatisms.
- MRI: left amygdala and temporal pole abnormal signal.
- PET: bilateral anterior temporal hypometabolism that is greater on left.
Interictal Misdirection
## Interictal Misdirection

Steinhoff, So, Lim, et al. (1995)

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Unitemporal</th>
<th>Bitemporal</th>
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<tbody>
<tr>
<td></td>
<td>Patients</td>
<td>Seizures</td>
</tr>
<tr>
<td></td>
<td>(n = 25)</td>
<td>(n = 136)</td>
</tr>
<tr>
<td>Bilateral independent seizures</td>
<td>1 (4%)</td>
<td>5 (45%)</td>
</tr>
<tr>
<td>Temporal asynchrony</td>
<td>1 (4%)</td>
<td>4 (3%)</td>
</tr>
<tr>
<td>Switch of lateralized ictal activity</td>
<td>3 (12%)</td>
<td>3 (2%)</td>
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* Fisher's two-tailed exact test.  
† Chi-square test.
Interictal Misdirection: Lessons

- Contralateral, homotopic discharges do not always indicate bilateral epilepsy.  
  - Warrant recording more seizures to assure lateralization.
- Consider each result in context of whole evaluation.
- Interictal localization may not be as reliable as ictal.
Ictal Misrepresentation

- 24 year old woman with seizures for 18 years.
- Childhood seizures: nocturnal emesis and GTCs.
- Current seizures: aura of nausea then staring with lip smacking, manual automatisms, and unresponsiveness.
- MRI: normal.
- PET: right temporal hypometabolism.
Ictal Misrepresentation
Ictal Misrepresentation
Ictal Misrepresentation

Remi, Vollmar, de Marinis et al. (2011)
Ictal Misrepresentation: Lessons

- Both ictal behavior and EEG ictal onset can arise from propagation.
- Consider each feature in the context of the whole evaluation.
- Ictal localization may not be as reliable as interictal.
Impact on Clinical Care

- EEG should be interpreted in its clinical context.
  - Is the history informative and accurate?
  - Are the imaging results expected and reliable?

- EEG’s limitations should be considered in its interpretation.
  - Are the interictal abnormalities expected?
  - Would an ictal recording help?
  - Is the ictal recording misleading?
Unmet Needs

• What are ictal EEG’s sensitivity and specificity?

• How can ictal EEG better indicate propagation?

• When can interictal EEG indicate epileptic focus?
  – Obviate seizure recording.
  – Identify one epileptic focus among multifocal interictal epileptiform discharges.
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ARS Question