Imaging and EEG in Post-traumatic Epilepsy

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Disclosure

Name
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Nature of Relationship
Consulting

Research Contracts with university

Sunovion, Eisai, UCB Pharma, Neuronex, Vertex, Upsher-Smith, Lundbeck, Neuropace, Medtronic
Learning Objectives

Discuss the utility of EEG and neuroimaging techniques in diagnosing post-traumatic epilepsy

Discuss how EEG and neuroimaging are used to assess prognosis in post-traumatic epilepsy
Diagnosis

- Diagnosis is clinically driven
- Reliance upon history
- Interictal EEG may aid in confirming clinical suspicion
  - Interictal spikes, focal slow waves, normal
- Ictal EEG may be necessary to establish diagnosis
  - Verify diagnosis of epileptic seizure
  - Verify diagnosis of psychogenic seizure or other non-epileptic event, e.g., syncope
Interictal EEG

Interictal spikes consistent with frontal or temporal contusions
Interictal EEG

EEG may suggest another etiology
## EEG and Brain Volume Loss in ml

### Vietnam Series

<table>
<thead>
<tr>
<th>EEG</th>
<th>Total</th>
<th>0-25</th>
<th>25-50</th>
<th>50-75</th>
<th>&gt; 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormally slow</td>
<td>173</td>
<td>62</td>
<td>51</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(36%)</td>
<td>(30%)</td>
<td>(14%)</td>
<td>(21%)</td>
</tr>
<tr>
<td>Epileptiform with</td>
<td>49</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>or without slowing</td>
<td></td>
<td>(14%)</td>
<td>(22%)</td>
<td>(14%)</td>
<td>(47%)</td>
</tr>
</tbody>
</table>

Jabbari et al Electroenceph Clin Neurophys 1986
# EEG and Seizures in PTE Vietnam Series

<table>
<thead>
<tr>
<th>Measure</th>
<th>Normal N = 239</th>
<th>Gen/foc slow N = 173</th>
<th>Epileptiform N = 49</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume Loss (mean in ml)</td>
<td>26</td>
<td>50</td>
<td>76</td>
<td>0.0001</td>
</tr>
<tr>
<td>Seizure</td>
<td>35%</td>
<td>63%</td>
<td>84%</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

*Jabbari et al Electroenceph Clin Neurophys 1986*
Ictal EEG-Video

Confirm diagnosis of epileptic seizure

Confirm classification of epilepsy (focal vs. generalized)

Yields clue regarding possible localization, which may be consistent with a traumatic etiology
MRI

- Provides evidence for the presence of a structural lesion
  - Supports presumed diagnosis of post-traumatic epilepsy
  - Location of lesion may be typical for PTE
    - Frontal, temporal or occipital pole
    - Beneath a depressed skull fracture
    - Establishes presence of blood or hemisiderin
    - If atypical, may lead to questioning diagnosis
CT: Contusion
MRI: Contusion
Certain MRI findings may lead to questioning diagnosis of PTE
MRI Lesion and PTE

- Lesion location and development of PTE
  - Cortical vs subcortical vs both
  - Single vs multiple lesions
  - Subdural hematoma vs intraparenchymal lesion

- Presence of hemosiderin and development of PTE
  - Location and prevalence limit accurate assessment
  - Walled vs incompletely walled lesions
Cumulative Probability of Developing PTE at 60 Months (20/184)

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>No. with PTE</th>
<th>Prob at 60 mo (%)</th>
<th>95% CI (%)</th>
<th>p Value (log-rank test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequelea of sSDH-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23</td>
<td>9</td>
<td>39.13</td>
<td>19.19-59.08</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No</td>
<td>112</td>
<td>11</td>
<td>9.82</td>
<td>4.31-15.33</td>
<td></td>
</tr>
<tr>
<td>No MRI lesion verses</td>
<td>21</td>
<td>1</td>
<td>4.76</td>
<td>0-13.87</td>
<td></td>
</tr>
<tr>
<td>H+G lesions only</td>
<td>29</td>
<td>7</td>
<td>24.14</td>
<td>8.56-39.71</td>
<td>0.067</td>
</tr>
<tr>
<td>G only</td>
<td>9</td>
<td>1</td>
<td>11.11</td>
<td>0-31.64</td>
<td>0.508</td>
</tr>
<tr>
<td>H only</td>
<td>33</td>
<td>2</td>
<td>6.06</td>
<td>0-14.2</td>
<td>0.824</td>
</tr>
<tr>
<td>H+G lesions + H</td>
<td>34</td>
<td>6</td>
<td>17.65</td>
<td>4.83-30.46</td>
<td>0.167</td>
</tr>
</tbody>
</table>

SDH-C: subdural/contusion; H: hemosiderin; G: gliosis

Messori et al 2005
Incomplete vs Complete Wall Around Hemosiderin Deposit

Incomplete wall lesions (and IW that later transform to CW lesions) have greater probability of developing PTE

Messori et al 2005
Blood-Brain Barrier and PTE

sLORETA identified delta and contrast enhancement with MRI

Tomkins et al. JNNP 2012
Blood-Brain Barrier Disruption and PTE

- 32 patients with head trauma – 17 had PTE
- Patients studied at varying intervals after trauma – 5 days to 18 years, though most late
- 80% of patients with PTE had MRI lesion
- 30.8% of patients without PTE had MRI lesion
- 76.9% of patients with PTE had BBB disruption vs. 33.3% of patients without PTE (p < 0.05)
- Volume of BBB disruption was significantly larger in patients with PTE (9.8 ± 2.6 vs 1.7 ± 0.6 cm³, p = 0.001

Tomkins et al. JNNP 2012
Diffuse Axonal Injury

Effect on cortical connections

Paterakis. J Trauma 2000
MRI Ascertainment of Lesions

A. Small hemorrhagic lesion in left occipital lobe
B. DWI shows same lesion
C. Trace map of diffusion shows same lesion
D. Lattice index (fractional anisotropy) shows decreased anisotropy in left internal capsule and anterior callosum

Arfanakis et al. AJNR 2002
Multimodal Imaging

High density EEG, fMRI

Relative Risk of PTE in 137 Patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Relative risk</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early seizures</td>
<td>8.58</td>
<td>2.87-25.65</td>
</tr>
<tr>
<td>Single CT lesion</td>
<td>3.43</td>
<td>1.23-9.57</td>
</tr>
<tr>
<td>Focal EEG</td>
<td>3.49</td>
<td>1.10-11.05</td>
</tr>
<tr>
<td>GCS</td>
<td>0.93</td>
<td>0.30-2.96</td>
</tr>
</tbody>
</table>

Angeleri F et al. Epilepsia 1999
Management

- Antiepileptic drugs – mainstay of therapy
- Surgery – for medically refractory cases
  - Best prognosis with single lesion
  - Multifocal EEG probably worse prognosis
  - History of trauma or other injury in adults associated with better surgical outcome (Mathern et al)
  - Role of multimodal assessment tools to be defined
Impact on Clinical Care and Practice

- EEG and MRI are used to aid in diagnosis and management of postraumatic epilepsy
- Different techniques elucidate different lesion types
  - Lesion type influences risk of PTE
  - Provide data to identify those at risk for developing PTE
- May be used to identify candidates for therapeutic intervention, e.g., anti-epileptogenesis