Seizures and hyperexcitable EEG patterns in primary intraventricular hemorrhage

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Seizures, periodic discharges and rhythmic patterns in primary intraventricular hemorrhage

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Background

- Primary intraventricular hemorrhage (pIVH) uncommonly presents with seizures
- EEG data on seizures and periodic and rhythmic patterns (PRPs) in neurocritically ill patients with intracranial hemorrhage, specifically in
  - Intracerebral
  - Subdural and
  - Subarachnoid hemorrhage

Marti-Fabregas J, et al. 1999
RodriguezRuiz A, et al. 2017
Gaspard N, et al. 2013
Chong DJ 2005
Claassen J, et al. 2007
Rudzinski LA, et al. 2011
Witsch J, et al. 2017
RHYTHMIC OR PERIODIC PATTERNS

All patterns recorded must consist of main term #1 followed by #2, with modifiers added as appropriate.

MAIN TERMS

1. **Generalized (G) OR Lateralized (L) OR Bilateral Independent (BI) OR Multifocal (Mf)**
   - Additional localizing information:
     - For L: Specify unilateral or bilateral asymmetric; and lobe(s) most involved or hemispheric
     - For BI or MF: Specify symmetric or asymmetric; and lobe(s) most involved or hemispheric in both hemisphere
     - For G: Specify frontally predominant, occipitally predominant, midline predominant or “truly” generalized

2. **Periodic Discharges (PDs) OR Rhythmic Delta Activity (RDA) OR Spike-Wave (SW; includes sharp-wave and polyspike-wave)**
   - **NOTE 1:** A pattern can qualify as rhythmic or periodic as long as it continues for at least 6 cycles (e.g. 1/s for 6 seconds, or 3/s for 2 seconds).
   - **NOTE 2:** If a pattern qualifies as both GPDs and RDA simultaneously, it should be coded as GPDs+ rather than RDA+ (see modifier 8 below)

Hirsch LJ, et al. 2013

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Periodic discharges (PDs)  
Rhythmic delta activity (RDA)

Courtesy of Emily Gilmore
Hyperexcitable EEG patterns

- Any PD’s, SW or RDA, including modifiers, except for GRDA
- Associated with an increased risk for seizures

RodriguezRuiz A, et al. 2017
Ictal-Interictal continuum (IIC)

- Periodic or rhythmic patterns, typically $>1 < 2.5$ Hz
  - LRDA, PDs and/or SW
- Patterns can be lateralized, generalized, bilaterally independent or stimulus-induced
- Not meeting criteria for definite electrographic seizures

Study Design & Methods

- Retrospective review of pIVH patients with cEEG as part of their routine clinical care at YNHH 1/2013-12/2016

- Recorded data
  - Demographics
  - cEEG indication
  - IVH extent by mGS, hydrocephalus and EVD location
  - Antiseizure medication use prior and during recording

- EEG data
  - Duration of cEEG monitoring
  - Electrographic vs. clinical seizures
  - Periodic and rhythmic patterns (PRPs), including IIC and GRDA, by location and morphology
Modified Graeb Score

Scores for each ventricle

<table>
<thead>
<tr>
<th>% of blood</th>
<th>R Temp Tip</th>
<th>R Lateral</th>
<th>R Post Tip</th>
<th>L Temp Tip</th>
<th>L Lateral</th>
<th>L Post Tip</th>
<th>IIIrd</th>
<th>IVth</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>≤ 25%</td>
<td>1</td>
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<td>1</td>
<td>2</td>
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<tr>
<td>&gt; 25% to ≤50%</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>2</td>
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<tr>
<td>&gt; 50% to ≤75%</td>
<td>2</td>
<td>3</td>
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<td>2</td>
<td>4</td>
<td>4</td>
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<tr>
<td>&gt; 75% to 100%</td>
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<td>4</td>
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<td>2</td>
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<td>4</td>
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<tr>
<td>Expanded</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

Morgan TC, et al. 2013
## Results

### Table 1. Demographic, radiologic and EEG data

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Entire group (N=11)</th>
<th>“Hyperexcitable group” (N=5)</th>
<th>“non-hyperexcitable group” (N=6)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years, IQR)</td>
<td>81(46-87)</td>
<td>80(59-84)</td>
<td>82(46-86)</td>
<td>0.26</td>
</tr>
<tr>
<td>Female, N (%)</td>
<td>7(64)</td>
<td>2(40)</td>
<td>5(83)</td>
<td>0.13</td>
</tr>
<tr>
<td>Hydrocephalus, N (%)</td>
<td>7(64)</td>
<td>5 (100)</td>
<td>2(33)</td>
<td>N/A</td>
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<tr>
<td>EVD, N (%)</td>
<td>7 (64)</td>
<td>5 (100)</td>
<td>2 (33)</td>
<td>-</td>
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<tr>
<td>mGS (IQR)</td>
<td>15(9-23)</td>
<td>17(12-22)</td>
<td>12(9-23)</td>
<td>0.28</td>
</tr>
<tr>
<td>Rhythmic and/or periodic patterns, N (%)</td>
<td>7 (64)</td>
<td>5</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>Electrographic seizures, N (%)</td>
<td>1 (9)</td>
<td>1(20)</td>
<td>0(0)</td>
<td>N/A</td>
</tr>
<tr>
<td>Monitoring duration in hours (IQR)</td>
<td>19 (12-156)</td>
<td>98(36-156)</td>
<td>18(12-38)</td>
<td>0.007</td>
</tr>
<tr>
<td>Monitoring sessions count, median (IQR)</td>
<td>1 (1-7)</td>
<td>5(1-7)</td>
<td>1(1-2)</td>
<td>0.08</td>
</tr>
</tbody>
</table>
## Results – EEG Data

### Table 2. Recorded EEG patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Antiseizure medication use</th>
<th>EVD location</th>
<th>Outcome (mRS)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDs (n=3)</td>
<td>RDA (n=5)</td>
<td>GSW</td>
<td>IIC</td>
</tr>
<tr>
<td>LP D</td>
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<tr>
<td>Patient</td>
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<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>3</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td></td>
<td></td>
<td>X</td>
<td>LEV/LAC/PHE</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td></td>
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</tbody>
</table>

**Abbreviations:**

ASM – antiseizure medication, EVD – external ventricular drain, I/L and C/L – location of EVD ipsilateral or contralateral to EVD if patterns include a unilateral pattern.

*mRS is a measure of disability ranging from 0 (no symptoms) to 6 (death).

PDs – periodic discharges, LPD (+R) – lateralized periodic discharges (+ rhythmicity), BIPD + R – bilateral independent periodic discharges (+ rhythmicity), GPD (+R) – generalized periodic discharges (+rhythmicity), RDA – rhythmic delta activity, LRDA (+S) – lateralized rhythmic delta activity (+sharps), GSW – generalized spike wave and/or sharp waves, IIC – ictal-interictal continuum. Note that GRDA is not a hyperexcitable pattern. LEV – levetiracetam, LAC – lacosamide, PHE – phenytoin.
Discussion

• In our cohort of patients with pIVH, 45% had hyperexcitable patterns and 9% electrographic seizures.
• Limitations include retrospective nature, sample size, potential selection bias and limited monitoring duration
• At present, all pIVH patients and impaired mental status and/or limited exam should be monitored with cEEG.
• Prophylactic ASM use is not currently recommended, but should be individualized, such as in patients with ICH
• Different hyperexcitable patterns confer varying seizure risk and may lead to hypoxia and metabolic crisis similar to seizures

RodriguezRuiz A, et al. 2017
Witsch J, et al. 2017
Discussion – Evolving understanding of PRPs

- LPDs are associated with seizures at 1Hz, but LRDA + GPDs only ≥ 1.5 Hz
  
  RodriguezRuiz A, et al. 2017

- In comatose SAH patients with intracranial EEG, PDs > 2Hz may be associated with brain tissue hypoxia

- In patients with severe TBI on intracranial EEG, PDs may trigger metabolic crisis similar to seizures

  Witsch J, et al. 2017
  Vespa P, et al. 2017
Significance

- This is the first analysis to our knowledge to examine seizures and PRPs in a small cohort of patients with pIVH.

- Based on our data, PRPs are common in pIVH, but these findings need to be validated in a larger cohort.

- The relationship between seizures and PRPs with IVH volume, EVD location/complications and hydrocephalus is not well understood.

- Even in the absence of evidence of radiographic cortical and subcortical brain injury, occurrence of these patterns may increase metabolic demand, promote secondary brain injury and be associated with worse outcomes.
Further areas of research

- Collect cEEG data on patients with pIVH, as a multicenter collaborative effort – CCEMRC
- Assess for predictors of seizures and PRPs
- Correlate EEG, including seizures, PRPs and degree of encephalopathy
  - with multimodal physiologic data
  - with functional outcome
Thank you

- Division of Emergency Neurology & Neurocritical Care, Yale University
  - Emily J. Gilmore, MD/MS
  - Kevin N. Sheth, MD

- Comprehensive Epilepsy Center, Yale University
  - Zubeda Sheikh, MBBS
  - Lawrence J. Hirsch, MD

- Division of Neurocritical Care, University of Florida
  - Carolina B. Maciel, MD
References