Periodic and Rhythmic Patterns

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Continuum of EEG Activity

**Clinical Correlate**
- Frequency, Duration, Rhythmicity, Location

**Neuronal Injury**
- GPDs
- LRDA
- LPDs +
- NCS
- NCSE

**SIRPIDs**
- Burst-Suppression
- LPDs
- BRDs

**Triphasics**
American Clinical Neurophysiology Society (ACNS): Critical Care EEG Terminology

Main Term #1
- Generalized
  G
- Lateralized
  L
- Bilateral Independent
  BI
- Multifocal
  Mf

Main Term #2
- Periodic Discharges
  PD s
- Rhythmic Delta Activity
  RDA
- Spike-wave
  SW
Main Term 1: Location

• Generalized
  — Symmetric in both hemispheres

• Lateraledized
  — Seen in only one hemisphere: unilateral
  — Seen in both hemispheres but asymmetric: Bilateral asymmetric

• Bilateral Independent
  — Seen in both hemispheres but Asynchronous

• Multifocal
Main term 2: Pattern Type

- **Periodic Discharge (PD)**
  - Repetition of a waveform with uniform morphology
  - **Quantifiable interval** between waveforms

- **Rhythmic Delta Activity (RDA)**
  - Repetition of a waveform with uniform morphology
  - **No interval** between consecutive waveforms
Modifiers

- Amplitude
- **Frequency**
- Prevalence (how much of the recording?)
- **Plus (superimposed Fast, Rhythmic, Sharp)**
- Stimulus Induced (SIRPIIDs)
- Triphasic Morphology
Lateralized Periodic Discharges: LPDs

Etiologies:
- Stroke
- Encephalitis (HSV)
- Tumor
- Intracranial hemorrhage

Clinical Correlates:
- Acute injury
- Encephalopathy
- Seizures in 50-90%
Lateralized Periodic Discharges
Lateralized Periodic Discharges Plus
Bilateral Independent Periodic Discharges (BIPDs)
Left Face Twitch: “ictal” LPDs
Generalized Periodic Discharges: GPDs

Etiologies:
- Anoxia
- Toxic metabolic
- Infections (CJD)
- Focal structural lesions

Clinical Correlate:

SEIZURES??
Outcome?
Patients with GPDs were matched by age, etiology, level of consciousness to patients without GPDs (200 each). 

<table>
<thead>
<tr>
<th>Event</th>
<th>GPDs</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any seizure during hospitalization</td>
<td>46%</td>
<td>34%</td>
</tr>
<tr>
<td>Non-convulsive seizure</td>
<td>27%</td>
<td>8%</td>
</tr>
<tr>
<td>NCSE</td>
<td>22%</td>
<td>7%</td>
</tr>
<tr>
<td>Mortality (univariate)*</td>
<td>36.8%</td>
<td>26.9%</td>
</tr>
</tbody>
</table>

*Multivariate predictors of worse outcome were cardiac arrest, coma, nonconvulsive status epilepticus, and sepsis, but not generalized periodic discharges.

Foreman et al, Neurology 2012
GPDs with Triphasic Morphology (old term: Triphasic Waves)

• High amplitude, positive discharge
• Each phase longer than the preceding
• Frontally predominant +/- A-P lag
• Hepatic or renal encephalopathy, anoxia, seizures?
Lateralized Rhythmic Delta Activity (LRDA)

27 patients/570 (4.7%)

Control populations

- Lateralized Periodic Discharges: $N = 49$
- Focal slowing: $N = 136$
- No focal, periodic or rhythmic pattern: $N = 241$

Gaspard et al. JAMA Neurology 2013
LRDA: Risk of acute seizures

Gaspard et al, JAMA Neurology, 2013
Generalized Rhythmic Delta Activity (GRDA)

- High amplitude, bisynchronous slow waves
- Typical frequency of 2-2.5 Hz
- Typically seen in toxic-metabolic disturbances
- May see with large midline structural lesions or increased ICP with herniation
Brief (potentially ictal) Rhythmic Discharges

B(i)RDs, BRDs

“Evolving rhythmic patterns... less than 10 seconds”
B(i)RDs and Association with Seizures

- 20 adult patients with B(i)RDs and compared to control groups

### Table 2. Occurrence of Seizures During CEEG

<table>
<thead>
<tr>
<th>CEEG Findings&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Seizure During CEEG, No. (%)</th>
<th>Univariate Analysis</th>
<th>Multivariate Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>P Value</td>
</tr>
<tr>
<td>B(i)RDs</td>
<td>15 (75)</td>
<td>5 (25)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>LPDs</td>
<td>16 (64)</td>
<td>9 (36)</td>
<td>.001</td>
</tr>
<tr>
<td>No B(i)RDs, no LPDs&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1 (4)</td>
<td>26 (96)</td>
<td>...</td>
</tr>
</tbody>
</table>

Abbreviations: B(i)RDs, brief potentially ictal rhythmic discharges; CEEG, continuous electroencephalography; LPDs, lateralized periodic discharges.

<sup>a</sup> Eleven patients had both B(i)RDs and LPDs.

<sup>b</sup> Reference group used for comparison.
SIRPIDS = Stimulus induced rhythmic, periodic or ictal discharges

- 33 of 150 pts. undergoing cEEG (22%)

- 50% experienced clinical or subclinical seizures during hospitalization

- Reactivity? Pathophysiology?
# Interrater Reliability of ICU EEG Research Terminology

**Ram Mani, * Hiba Arif, † Lawrence J. Hirsch, ‡ Elizabeth Gerard, § and Suzette LaRoche||**

<table>
<thead>
<tr>
<th>Term</th>
<th>% Agreement (SD)</th>
<th>Kappa (95% CI)</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Term 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generalized</td>
<td>96% (7%)</td>
<td>.87 (.75-.98)</td>
<td>Almost Perfect</td>
</tr>
<tr>
<td>Lateralized</td>
<td></td>
<td></td>
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<tr>
<td>Bilateral Independent</td>
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<td></td>
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<tr>
<td>Multifocal</td>
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<tr>
<td><strong>Main Term 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodic Discharges</td>
<td>98% (3%)</td>
<td>.92 (.78-.98)</td>
<td>Almost Perfect</td>
</tr>
<tr>
<td>Rhythmic Delta Activity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Spike-Wave</td>
<td></td>
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<tr>
<td><strong>Modifiers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amplitude</td>
<td>93% (12%)</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>80% (20%)</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>+ Fast</td>
<td>83% (18%)</td>
<td>.54 (.16-.87)</td>
<td>Fair</td>
</tr>
<tr>
<td>+ Rhythmic Activity</td>
<td>88% (20%)</td>
<td>.62 (.41-.87)</td>
<td>Moderate</td>
</tr>
<tr>
<td>+ Sharp or Spike</td>
<td>82% (20%)</td>
<td>.16 (.10-.28)</td>
<td>Poor</td>
</tr>
</tbody>
</table>

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Mani et al Journal Clin Neurophysiol 2012
Periodic and Rhythmic Patterns: Association with Seizures

- Retrospective, 3-center review of 4772 critically ill adults undergoing CEEG

- Seizures were documented in 719 (12.5%) of which 530 (74%) also had a periodic or rhythmic pattern
Periodic and Rhythmic Patterns:

Association with Seizures

Rodriguez et al, presented at AES, December 2015
Case

• 66 yo man with 4 months of cognitive decline and gait instability

• **Medications**: Methadone, Diazepam

• **Neurological Exam**: Oriented to person only, bilateral visual field deficits, strength intact, reflexes brisk throughout, multifocal myoclonus, unable to stand

• **Initial Diagnostic Tests**:
  • MRI partially obscured due to movement artifact but essentially unremarkable
  • CSF – Protein 35, Glucose 67, WBC 3/4
Lateralized Periodic Discharges (LPDs)- Not Ictal

Load Fosphenytoin 20 mg/kg/PE
2 weeks later....

**CSF Analysis**: 14, 3, 3 Protein Tau/Theta Positive

**Clinical Diagnosis**: Creutzfeldt – Jacob Disease

**Deceleration of Care**
Case

• 85 yo admitted for fever, productive cough and confusion

• **Medications**: Albuterol, Lisinopril

• **Neurological Exam**: Lethargic, oriented to person only, unable to follow commands, otherwise non focal neurological exam

• **Chest X ray**: Bilateral pulmonary infiltrates

• **Brain MRI**: Mild generalized volume loss
EEG 2 Days later: No improvement in mental status
Generalized Periodic Discharges (GPDs), 1.5-2 Hz, with triphasic morphology
5 min after Lorazepam 2 mg: Awake, Follows Commands
Case

• 44 yo woman with shortness of breath and confusion

• **Medications:** Oxycodone

• **Urine Drug Screen:** Positive for opiates, benzodiazepines

• **Head CT:** Unremarkable

• Intubated and sedated (with propofol) secondary to respiratory distress, possible overdose

• Neurology consult 2 days later for persistent confusion
EEG During Propofol Wean: Generalized Rhythmic Delta Activity (GRDA), 2 Hz, Plus Sharp
Also.... Fluctuating
Also... Stimulus Induced Rhythmic, Periodic or Ictal Discharges (SIRPIIDs)
Next day, propofol off.....transferred out of ICU
Summary

- Periodic and rhythmic patterns are common in the critically ill, many of which have increased association with seizures

- Standardized terminology is critical for consistency in clinical reporting and research

- Medical decisions need to take into account the EEG pattern AND clinical history