Cartoons describing graphoelements and patterns

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**Symmetry – voltage:**

**Symmetric**
- LEFT: 60µV
- RIGHT: 60µV

**Mild asymmetry**
- LEFT: 60µV
- RIGHT: >30µV

Consistent but <50% voltage difference between sides (on appropriate referential recording).
Symmetry – frequency:

**Symmetric**

<0.5 Hz difference between sides

**Mild asymmetry**

0.5–1 Hz difference between sides
Symmetry – voltage:

Marked asymmetry:

≥50% voltage difference between sides (on appropriate referential recording).

Note: 30µV as 50% of 60µV

Symmetry – frequency:

Marked asymmetry:

>1 Hz difference between sides
Continuity:

Attenuation or suppression, % of recording (≥1 s)

- **Continuous**
  - <1%

- **Nearly continuous**
  - 1 to 9%

- **Discontinuous**
  - 10 to 49%

- **Burst-attenuation/Burst-suppression**
  - 50 to 99%

- **Attenuation/Suppression**
  - >99%

**Attenuation:** ≥ 10 µV, < 50% of higher voltage background
**Suppression:** < 10 µV
“Discharge“ versus “Burst“:

Discharge

"<0.5 s regardless of phases“

OR

"≥0.5 s and ≤3 phases“

Burst

"≥0.5 s and ≥4 phases“

"Bursts must be ≤30 s“

*phase: an area under the curve on one side of the baseline. See Main modifier (d) below.
Attenuation Percent or Suppression Percent:

*Attenuation Percent or Suppression Percent:* the percent of the record/epoch that is attenuated or suppressed. This can range from 1% to 99%. If <1%, it is considered continuous. If >99%, it is considered either suppressed or attenuated, but not discontinuous. **For example, a record with 2 second bursts alternating with 8 seconds of suppression would be Burst-Suppression with a suppression percent of 80%**.

Suppression percent of 80%.
Highly Epileptiform Bursts

1. Two or more epileptiform discharges (spikes or sharp waves),
2. within the majority (>50%) of bursts, and
3. occur at an average of 1 Hz or faster within a single burst

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1. EDs at 1.5 Hz
2. EDs at 2.5 Hz
3. on average: ≥1Hz

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Dotted lines represent longer duration of suppression for reasons of presentation; ED epileptiform discharge
Highly Epileptiform Bursts

1. A rhythmic, potentially ictal –appearing pattern,
2. within the majority (>50%) of bursts

... dotted lines represents longer duration of suppression for reasons of presentation;

majority (>50%) of bursts with rhythmic potentially ictal-appearing pattern

burst **with** rhythmic potentially ictal appearing pattern
burst **with** rhythmic potentially ictal appearing pattern
burst **without** rhythmic potentially ictal appearing pattern
The first 0.5 s or longer of each burst is visually similar in all channels in the vast majority (>90%) of bursts
Identical Bursts in a Stereotyped Cluster

The first 0.5 s or longer of each of **two or more** bursts in a stereotyped cluster are visually similar in all channels in the vast majority (>90%) of bursts.
State changes:

At least 2 sustained types of background EEG:
1. Related to level of alertness or stimulation.
2. Each must persist at ≥60 s to qualify as a “state”.
3. Stimulation should be able to transition the patient from the less alert to more alert/more stimulated state.
4. The more alert/more stimulated state is considered the “reported background” EEG.
5. State changes can also occur spontaneously.

STIM = stimulation, Spont. = spontaneous

EEG background 1: stimulated/more awake: used for background feature description (“reported background“)
EEG background 2: unstimulated/less awake state; commonly lasts minutes to hours (minimum: 60 s)
Cyclic Alternating Pattern of Encephalopathy (CAPE):

Changes in EEG background patterns 1 and 2:
1. each lasting at least 10 s,
2. \textbf{spontaneously} alternating between the two patterns in a regular manner,
3. for at least 6 cycles.

NOTE: If each pattern of CAPE lasts >60 seconds, this would qualify as presence of state changes. If CAPE is always present, cannot be interrupted with stimulation, and at least one of the states lasts <60 seconds, it remains possible for a patient to have CAPE and no state changes.
Anterior-posterior (AP) gradient:

- Anterior-posterior (AP) gradient
- Reversed AP gradient

- Anterior
- Posterior

- At least 1 continuous minute
Sporadic Epileptiform Discharges:

- **Spike** (which is epileptiform) - 20 to <70 ms
- **Sharp Wave** (which is epileptiform) - 70 to 200 ms
- **Polyspike** (which is epileptiform) - <0.5 s
- **Sharply Contoured Wave** (which is not epileptiform) - >200 ms

**Blunt**: having smooth or sinusoidal morphology.

(duration measured at baseline)
Polyspike versus BIRD versus Highly Epileptiform Burst:

1. Two or more spikes,
2. occurring in a row with no interdischarge interval,
3. lasting <0.5 s.

Polyspike

duration <0.5 s:

BIRD

duration ≥0.5 s:

Brief Potentially Ictal Rhythmic Discharge

Highly Epileptiform Burst

or, if alternating with suppression or attenuation, a highly epileptiform burst within burst suppression/attenuation
Lateralized Periodic Discharges (LPDs)

- **LEFT**: Periodic discharges over the left
Bilateral Independent Periodic Discharges (BIPDs)

Note: In BIPDs, lateralized patterns occur on each hemisphere asynchronously and at different frequencies. It does not matter that they occur with a maximum over different regions.
Unilateral Independent Periodic Discharges (UIPDs):

Longitudinal bipolar montage

LEFT

Periodic discharges over left anterior

Periodic discharges over left posterior

RIGHT
Multifocal Periodic Discharges (MfPD):

Note: In MfPD, periodic discharges occur in three independent locations simultaneously with at least one in each hemisphere.
Periodic Discharges (PDs):

1. Repetition of a waveform with relatively uniform morphology and duration,
2. with a **clearly discernable inter-discharge interval** between consecutive waveforms, and
3. recurrence of the waveform at nearly regular intervals: having a cycle length (i.e., period) varying by <50% from one cycle to the next in the majority (>50%) of cycle pairs.

A pattern can qualify as rhythmic or periodic if and only if it continues for at least 6 cycles (e.g. 1 Hz for 6 seconds, or 3 Hz for 2 seconds).
Rhythmic Delta Activity (RDA):

1. Repetition of a waveform with relatively uniform morphology and duration, and
2. without an interval between consecutive waveforms.
3. The duration of one cycle (i.e., the period) of the rhythmic pattern should vary by <50% from the duration of the subsequent cycle for the majority (>50%) of cycle pairs to qualify as rhythmic.

A pattern can qualify as rhythmic or periodic if and only if it continues for at least 6 cycles (e.g. 1 Hz for 6 seconds, or 3 Hz for 2 seconds).
**“Spike and Wave” or “Sharp and Wave” (SW):**

Spike-and-wave or Sharp-and-wave (SW): Polyspike, spike or sharp wave consistently followed by a slow wave in a regularly repeating and alternating pattern (spike-wave-spike-wave-spike-wave), with a consistent relationship between the spike (or polyspike or sharp wave) component and the slow wave for at least 6 cycles; and with no interval between one spike-wave complex and the next (if there is an interval, this would qualify as PDs, where each discharge is a spike-and-wave).
**Number of Phases**

Number of Phases = 1 + number of baseline crossings of the typical discharge. In this case there are a total of 2 baseline crossings, therefore the number of phases is $1 + 2 = 3$ phases. A phase is the part of the signal above or below the imaginary baseline. In this case phase 1 (pink) is above, phase 2 (blue) is below and phase 3 (yellow) is above again.
At least 2 unequivocal, sequential changes in frequency defined as follows: Evolution in frequency is defined as at least 2 consecutive changes in the same direction by at least 0.5 Hz. In order to qualify as present, a single frequency must persist for at least 3 cycles. The criteria for evolution must be reached without the evolving feature (frequency) remaining unchanged for 5 or more continuous minutes.

1st change: 5 Hz to 3 Hz
2nd change: 3.0 Hz to 2.0 Hz

5.0 Hz 3.0 Hz 2.0 Hz

Evolution of frequency
Evolution in morphology is defined as at least 2 consecutive changes to a novel morphology. The two consecutive changes must be in the same category (morphology) to qualify. To qualify as evolution in morphology, each different morphology or each morphology plus its transitional forms must last at least 3 cycles.
Evolution in location is defined as sequentially spreading into or sequentially out of at least two different standard 10-20 electrode locations. The two consecutive changes must be in the same category (location) to qualify. In order to qualify as present, a single location must persist for at least 3 cycles.

**EXAMPLE A**

<table>
<thead>
<tr>
<th>Location 1: anterior (F3)</th>
<th>Location 2: anterior + central (F3+C3)</th>
<th>Location 3: wide field parasagittal (F3+C3+P3)</th>
</tr>
</thead>
</table>

Cycle 1 2 3

FP1-F3
F3-C3
C3-P3
P3-O1
Evolution of location

EXAMPLE B

1st change

2nd change

Longitudinal bipolar

FP1-F3

F3-C3

C3-P3

P3-O1

FP1-F7

F7-T7

T7-P7

P7-O1

anterior temporal

spread to include posterior temporal

spread to include parasagittal

Cycle 1 2 3
>3 changes, not more than one minute apart, in frequency (by at least 0.5 Hz), but not qualifying as evolving. This includes patterns fluctuating from 1 to 1.5 to 1 to 1.5 Hz. In order to qualify as present, a single frequency must persist at least 3 cycles (e.g. 1 Hz for 3 s, or 3 Hz for 1 s).
Fluctuating morphology

≥3 changes, not more than one minute apart, in morphology, but *not qualifying as evolving*. This includes patterns alternating between 2 morphologies repeatedly. In order to qualify as present, a single morphology must persist at least 3 cycles.
Fluctuating location

>3 changes, not more than one minute apart, in location (by at least 1 standard inter-electrode distance), but not qualifying as evolving. This includes patterns spreading in and out of a single electrode repeatedly. In order to qualify as present, a single location must persist at least 3 cycles.

EXAMPLE A

1st change (F3 to F3/C3) < 1min 2nd change (F3/C3 to F3) < 1min 3rd change (F3 to F3/C3)

Longitudinal bipolar

FP1-F3

F3-C3

C3-P3

P3-O1

Location 1 Location 2 Location 1 Location 2
Fluctuating location

EXAMPLE B

1st change
2nd change
3rd change

FP1-F3
F3-C3
C3-P3
P3-O1

FP1-F7
F7-T7
T7-P7
P7-O1

Longitudinal bipolar

<1 min

anterior temporal only
spread to parasagittal
anterior temporal only
spread to parasagittal
Lateralized Periodic Discharges PLUS fast activity (LPDs+F)

code as +F if the fast activity is part of the RDA or PD pattern and not simply part of the background activity

EXAMPLE A: LPD+F

NOTE: fast activity cycling with the periodic discharge
Lateralized Periodic Discharges PLUS *fast* activity (LPDs+F)

code as +F if the fast activity is part of the RDA or PD pattern and not simply part of the background activity

EXAMPLE C: LPD+F

EXAMPLE D: LPD *(NOT +F, as fast activity is part of the background and present even when the pattern is not)*
Rhythmic Delta Activity PLUS *fast* activity (RDA+F)

If a pattern qualifying as RDA or PDs has associated continuous fast frequencies (theta or faster), this can and should be coded as +F if the fast activity is not present in the background activity when the RDA or PDs is not present.

**EXAMPLE A:** RDA+F (also qualifies as definite EDB if the RDA is abundant or continuous, or possible EDB if occasional or frequent)

**EXAMPLE B:** RDA+F (also qualifies as definite EDB if the RDA is abundant or continuous, or possible EDB if occasional or frequent)

NOTE: fast activity cycling with the rhythmic delta and having a stereotyped relationship to the delta wave

EDB = Extreme Delta Brush
If a pattern qualifying as RDA or PDs has associated continuous fast frequencies (theta or faster), this can and should be coded as +F if the fast activity is not present in the background activity when the RDA or PDs is not present.

EXAMPLE C: RDA+F (also qualifies as possible EDB if the RDA is abundant or continuous)

EXAMPLE D: RDA *(NOT +F, as fast activity is part of the background and present even when the pattern is not; NOT EDB since not RDA+F or periodic delta bushes)*
Periodic Discharges PLUS RDA (PD+R)

RDA occurring at the same time as PDs but *without* time-locked association with the PDs would qualify as PD+R.

**EXAMPLE A: PD+R**

![Graphical representation of PD+R]

**EXAMPLE B: NOT PD+R;** instead this is **SW (sharp-and-wave):** consistent relationship (*time-locked association*) between the sharp wave component and the slow wave.

![Graphical representation of SW]

**NOTE:** spikes are *not* time-locked to delta-waves
Generalized rhythmic delta activity with associated spikes in one hemisphere only (RDA on one side and synchronous RDA+S on the other) would qualify for GRDA+S.
Note: bilateral independent periodic discharges with fast activity in one hemisphere only (PD on one side, and PD+F on the other) would qualify for BIPDs+F.
# Relationship between RDA+F, PD+F and Extreme Delta Brush (EDB)

<table>
<thead>
<tr>
<th></th>
<th>RDA+F; or PD+F if (and only if) the PDs are blunt delta waves</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continuous/ Abundant</strong></td>
<td><strong>Frequent/Occasional</strong></td>
</tr>
<tr>
<td><strong>(≥50% of record/epoch)</strong></td>
<td><strong>(≥1 to 49% of record/epoch)</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fast activity WITH stereotyped relationship to delta wave</th>
<th>Definite EDB</th>
<th>Possible EDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast activity WITHOUT stereotyped relationship to delta wave</td>
<td>Possible EDB</td>
<td>RDA+F or PD+F, but NOT EDB</td>
</tr>
</tbody>
</table>

### 3. Main Modifiers:

a. **Prevalence:**
   i. Continuous: ≥90% of record/epoch.
   ii. Abundant: 50-89% of record/epoch.
   iii. Frequent: 10-49% of record/epoch.
   iv. Occasional: 1-9% of record/epoch.
   v. Rare: <1% of record/epoch.
Extreme Delta Brush (EDB):

This is a subset +F, with **abundant or continuous** RDA+F or PD+F (only if the PDs are blunt delta waves), where the fast activity has a **stereotyped relationship** to each delta wave.

**EXAMPLE A:**
RDA+F and EDB  
(stereotyped relationship)

**EXAMPLE B:**
RDA+F, **NOT** EDB  
(requires 6 cycles of stereotyped fast activity)

**EXAMPLE C:**
PD+F and EDB

**EXAMPLE D:**
PD+F, **NOT** EDB  
(not blunt delta waves)
Extreme Delta Brush (EDB): RDA subtype

This is a subset of RDA+F, with abundant or continuous RDA, with superimposed fast on each delta wave, in which the fast has a stereotyped relationship to the delta wave.

EXAMPLE A: RDA+F and definite EDB (stereotyped relationship)

EXAMPLE B: RDA+F and definite EDB (stereotyped relationship)

EXAMPLE C: RDA+F and possible EDB (NO stereot. relationship)

EXAMPLE D: RDA but NOT +F and NOT EDB
Extreme Delta Brush (EDB): PD subtype

This is a subset of PD+F, with abundant or continuous PD, with superimposed fast on each delta wave, in which the fast has a stereotyped relationship to the periodic discharge.

**EXAMPLE A:**
PD+F and definite EDB  
(stereotyped relationship)

**EXAMPLE B:**
PD+F, **NOT** EDB  
(no fast on the waveform)

**EXAMPLE C:**
PD+F and definite EDB  
(stereotyped relationship)

**EXAMPLE D:**
PD+F, possible EDB  
(NO stereot. relationship)

**EXAMPLE E:**
PD but **NOT** +F and **NOT** EDB
Extreme Delta Brush (EDB):

EXAMPLE A: GRDA+F (also qualifies as generalized EDB: definite EDB if the RDA+F is abundant or continuous; possible EDB if the RDA+F is occasional or frequent)
Extreme Delta Brush (EDB):

EXAMPLE B: LRDA+F (also qualifies as lateralized EDB: definite EDB if the LRDA+F is abundant or continuous; possible EDB if the LRDA+F is occasional or frequent)
Extreme Delta Brush (EDB):

EXAMPLE C: BIRDA+F (also qualifies as bilateral independent EDB: definite EDB if the BIRDA+F is abundant or continuous; possible EDB if the BIRDA+F is occasional or frequent)
Anterior-posterior (AP) lag:

- Anterior-posterior lag:
- Posterior-anterior lag:

>100 ms: AP-delay

>100 ms: PA-delay
Electrographic seizure (ESz):

Epileptiform discharges \( \geq 2.5 \text{ Hz} \) for \( \geq 10 \text{ s} \) (\( >25 \text{ ED in } 10 \text{s} \))

Example: 26 EDs per 10 s

OR

Any pattern with definite evolution lasting \( \geq 10 \text{ s} \)
Electroclinical seizure (ECSz): Any EEG pattern with either:

Definite clinical correlate time-locked to the pattern (of any duration)

OR

EEG AND clinical improvement with a parenteral (typically IV) anti-seizure medication
Electroclinical seizure (ECSz): For patients with prior known epileptic encephalopathy

**Current EEG**

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**Baseline EEG**

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**OR**

Any EEG pattern with EEG **AND** clinical improvement after a parenteral (typically IV) anti-seizure medication

- an increase in prominence or frequency of epileptiform discharges compared to baseline,
- an observable decline in clinical state

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anti-seizure medication

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clinical improvement

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EEG-improvement
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

Focal (including L, BI, UI or Mf) or generalized rhythmic activity >4 Hz (at least 6 waves at a regular rate) lasting ≥0.5 to <10 s
1. not consistent with a known normal pattern or benign variant,
2. not part of burst-suppression or burst-attenuation,
3. without definite clinical correlate, and
4. that has at least one of the following features:

a. Evolving BIRDs (a form of definite BIRDs)

<table>
<thead>
<tr>
<th>0.5s</th>
<th>1s</th>
<th>2s</th>
<th>3s</th>
<th>4s</th>
<th>5s</th>
<th>6s</th>
<th>7s</th>
<th>8s</th>
<th>9s</th>
<th>10s</th>
</tr>
</thead>
</table>

(≥0.5 s, >4 Hz, but at least 6 waves at regular rate)

BIRD:
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. Similar morphology and location as interictal epileptiform discharges or seizures in the same patient (definite BIRDs)

Interictal epileptiform discharges in same patient:
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. Similar morphology and location as interictal epileptiform discharges or seizures in the same patient (definite BIRDs)

seizure in same patient:
Brief Potentially Ictal Rhythmic Discharges (BIRDs):

c. Sharply contoured but without (a) or (b) (possible BIRDs)
The Ictal-Interictal Continuum (IIC):

Does not qualify as an electrographic seizure or electrographic status epilepticus, but can be considered with any of the following features:

A. Any PD or SW pattern that averages >1.0 Hz and ≤2.5 Hz over 10 s (>10 and ≤25 discharges in 10 s);

Epileptiform discharges > 1.0 Hz and ≤2.5 Hz over 10 s (>10 and ≤25 ED in 10 s)

**PD**

Example: 12 EDs per 10 s

**SW**

Example: 18 EDs per 10 s

*to be continued*
The Ictal-Interictal Continuum (IIC):

B. Any PD or SW pattern that averages \( \geq 0.5 \) Hz and \( \leq 1.0 \) Hz over 10 seconds (\( \geq 5 \) and \( \leq 10 \) discharges in 10 s), AND has a plus modifier or fluctuation;

*PLUS-MODIFIERs*

**PD+F**

**PD+R**

**PD+FR**

OR

to be continued
The Ictal-Interictal Continuum (IIC):

B. Any PD or SW pattern that averages ≥0.5 Hz and ≤1.0 Hz over 10 seconds (≥5 and ≤10 discharges in 10 s), AND has a plus modifier or fluctuation;

OR
The Ictal-Interictal Continuum (IIC):

C. Any lateralized RDA (LRDA, BIRDA, UIRDA, MfRDA) averaging >1 Hz for ≥10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation.
The Ictal-Interictal Continuum (IIC):

C. Any lateralized RDA (LRDA, BIRDA, UIRDA, MfRDA) averaging >1 Hz for at ≥10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation.