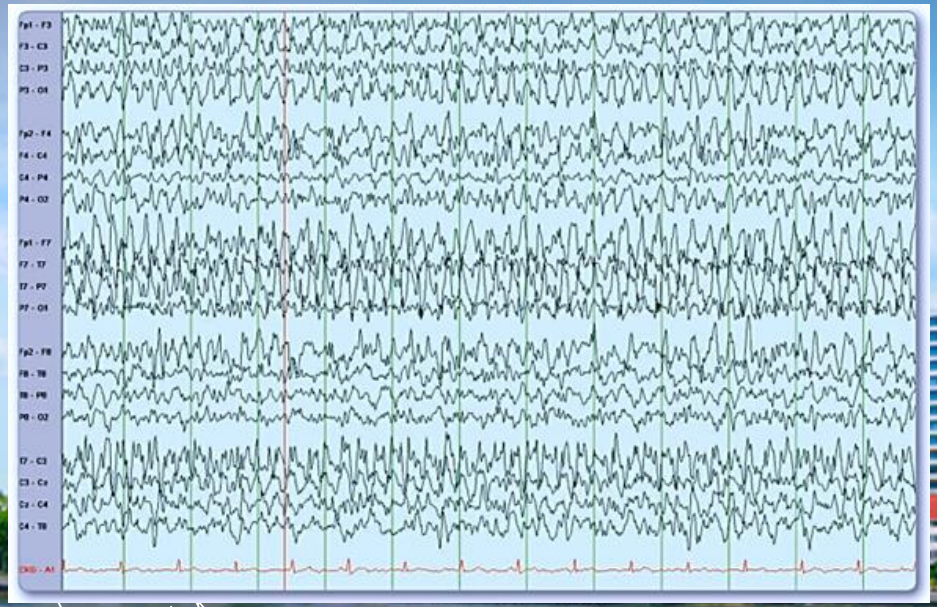
มหาวิทยาลัยมหิดล
คณะแพทยศาสตร์
ศิริราชพยาบาล

SI-NEURO

NCSE: Real World Diagnostic Challenge

Salzburg Criteria, Borderline, Pitfalls



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NCSE: EEG criteria

1996 Young's criteria for NCS/NCSE

2007 Kaplan working diagnostic criteria

2013 Unified EEG terminology and criteria for NCSE

2015 Salzburg Consensus Criteria for NCSE

NCSE: EEG criteria

1996 Young's criteria for NCS/NCSE → 2007 Kaplan working diagnostic criteria → 2013 Unified EEG terminology and criteria for NCSE → 2015 Salzburg Consensus Criteria for NCSE

Primary Criteria

1. Repetitive generalized or focal EDs at ≥3Hz
2. Repetitive generalized or focal EDs at <3Hz and secondary criteria
3. Sequential rhythmic waves and secondary criteria

Secondary Criteria

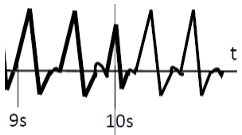
1. Incrementing onset: ↑ in volt, ↑/↓ of freq
2. Decrementing offset: ↓ in volt or freq
3. Post-discharge slowing or volt attenuation
4. Sig improvement in clinical state or baseline EEG after AED

General Concept

1.Clinical

2.EEG

Epileptic



ED

or

RDA

3.Pattern

Freq cut point

or

Clinical time-lock

or

Evolution

Definite NCSE

Possible NCSE

Borderline: IIC, fluctuation

ASM

Improvement:
1. Clinical
2. EEG

NCSE: EEG criteria

1996 Young's criteria for NCS/NCSE → **2007 Kaplan working diagnostic criteria** → 2013 Unified EEG terminology and criteria for NCSE → 2015 Salzburg Consensus Criteria for NCSE

Without known Epileptic Encephalopathy (EE)

1) Repetitive feneralized or focal ED >2.5Hz
2) <2.5Hz + clinical & EEG improvement after ASM; esp BZP
3) <2.5Hz + focal ictal phenomena; facial twitching, gaze deviate, limb myoclonus
4) Rhythmic waves >0.5Hz + a) incrementing onset b) evolution patterns (freq, location, morphology) c) decrementing termination d) post-PED

With known EE

1) Frequent or continuous ED, ↑ from baseline w/ changes in clinical
2) Improvement of clinical or EEG after IV BZP

Adapted from Kaplan P. Epilepsia, 48(Suppl. 8):39–41, 2007

EEG criteria for nonconvulsive status epilepticus

Peter W. Kaplan

In patients without a known epileptic encephalopathy

1) Repetitive generalized or focal spikes, polyspike, sharp waves, spike-and-wave or sharp-and-slow wave complexes at >2.5/second.
2) Above, with discharges <2.5/second but with EEG and clinical improvement after rapid onset antiepileptic drugs, typically BZPs. Testing for patient responsiveness *and* improvement in EEG; increases in EEG reactivity and appearance of EEG background activity.
3) Above, with discharges < 2.5/sec with focal ictal phenomena (e.g., facial twitching, gaze deviation, nystagmus, limb myoclonus).
4) Rhythmic waves (theta-delta) at >0.5 Hz with *a)* incrementing onset (increase in voltage with increase or decrease in frequency), *b)* evolution in pattern (increase or decrease in frequency (>1 Hz), or location [changes in discharge voltage (amplitude) or morphology are not sufficient], or *c)* decrementing termination (voltage or frequency), *d)* post-PEDs background slowing or attenuation. *A,b,c* may be acutely abolished by IV BZPs.

In patients with known epileptic encephalopathy

1) Frequent or continuous generalized spike-wave discharges, which show an increase in profusion or frequency when compared to baseline EEG with observable change in clinical state.
2) Regression (improvement) of clinical or EEG features with IV BZPs.

Kaplan P. Epilepsia, 48(Suppl. 8):39–41, 2007

NCSE: EEG criteria

1996 Young's criteria for NCS/NCSE → 2007 Kaplan working diagnostic criteria → **2013 Unified EEG terminology and criteria for NCSE** → 2015 Salzburg Consensus Criteria for NCSE

Table 1. Working clinical criteria for nonconvulsive status epilepticus

Patients without known epileptic encephalopathy
- EDs > 2.5 Hz, *or*
- EDs ≤ 2.5 Hz or rhythmic delta/theta activity (>0.5 Hz) AND one of the following:
  - EEG and clinical improvement after IV AED[a], *or*
  - Subtle clinical ictal phenomena during the EEG patterns mentioned above, *or*
  - Typical spatiotemporal evolution[b]

Patients with known epileptic encephalopathy
- Increase in prominence or frequency of the features mentioned above, when compared to baseline **with** observable change in clinical state
- Improvement of clinical and EEG[a] features with IV AEDs

Epilepsia, 54(Suppl. 6):28–29, 2013

NCSE: EEG criteria

1996 Young's criteria for NCS/NCSE → 2007 Kaplan working diagnostic criteria → 2013 Unified EEG terminology and criteria for NCSE → **2015 Salzburg Consensus Criteria for NCSE**

EEG data:

EEG changes fulfilling the criteria have to be continuously present for ≥ 10 s. Criteria not applicable to physiological graphoelements.

A: Patients without known epileptic encephalopathy (at least ONE of the criteria 1–3 should be fulfilled for diagnosis of NCSE)

1. EDs > 2.5 Hz (i.e., >25 EDs in "worst" 10-second epoch)
2. Typical ictal spatiotemporal evolution* of:
   - (2a) EDs OR
   - (2b) Rhythmic activity** (>0.5 Hz)
3. Subtle ictal clinical phenomena*** with:
   - (3a) EDs OR
   - (3b) Rhythmic activity** (>0.5 Hz)
4. If criteria 1–3 are not fulfilled, but one of the following patterns is present, apply appropriate AED(s) after careful consideration of clinical situation and document response****:
   - (4a) EDs ≤ 2.5 Hz with fluctuation***** OR
   - (4b) Rhythmic activity** (>0.5 Hz) with fluctuation***** OR
   - (4c) Rhythmic activity** (>0.5 Hz) without fluctuation*****

B: Patients with known epileptic encephalopathy

In addition to the criteria above (A), these patients have to fulfill one of the following:

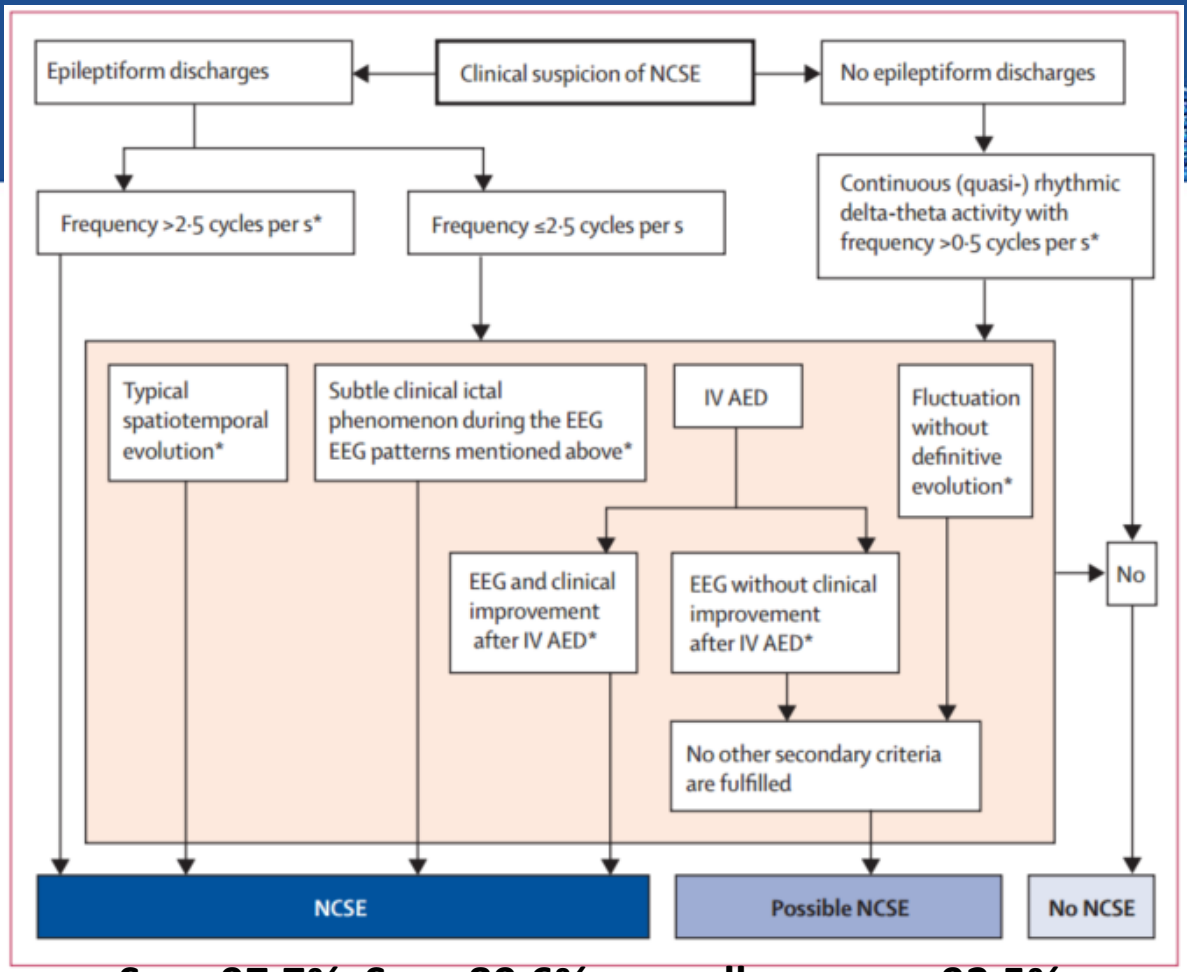
- Increase in prominence or frequency when compared to baseline *with* observable change in clinical state
- Improvement of clinical and EEG features with IV AEDs (see A.4.)

Clinical data:

Add clinical information for establishing the diagnosis of NCSE:

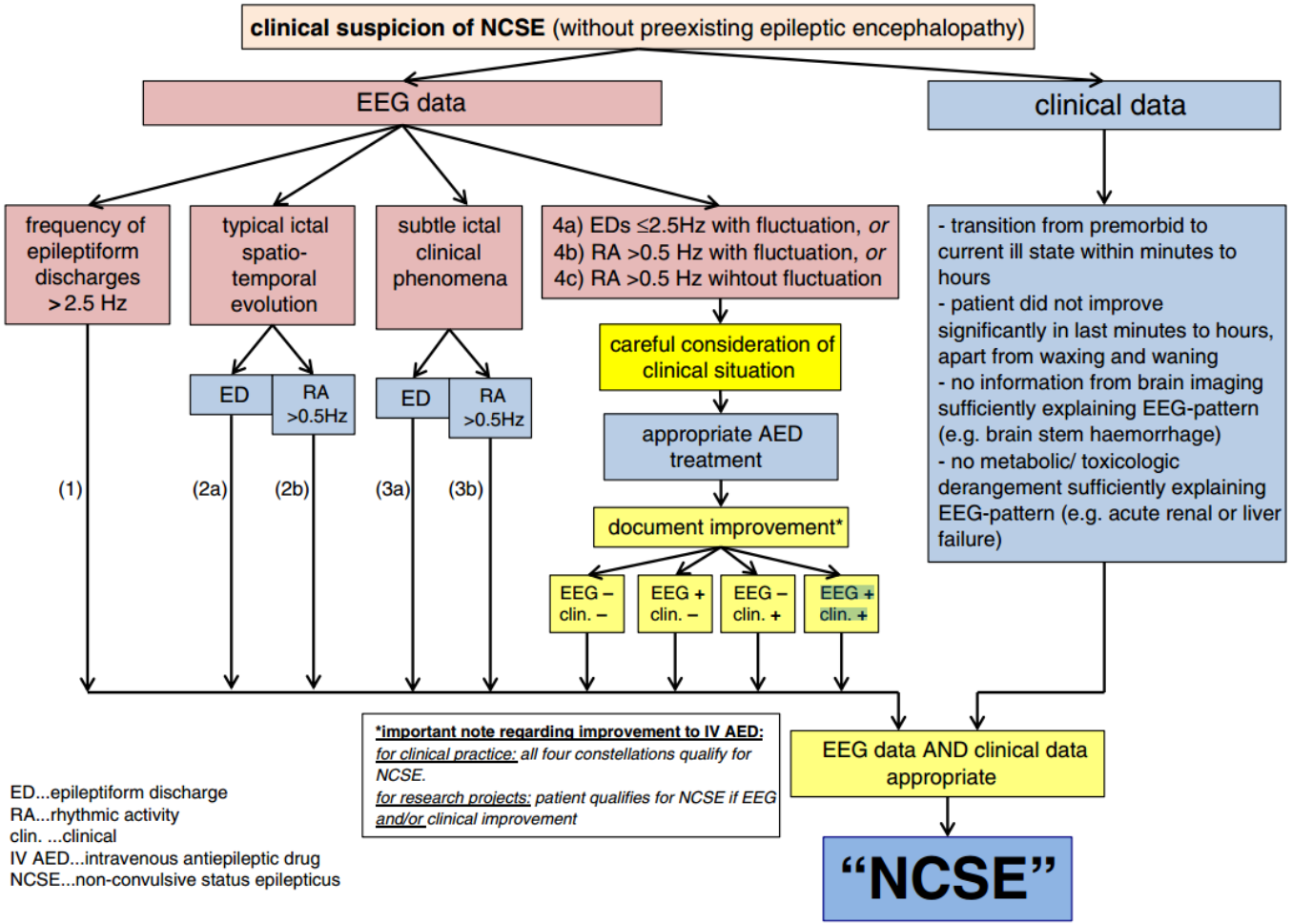
- Transition from premorbid to current ill state within minutes to hours
- Patient did not improve significantly in last minutes to hours, apart from waxing and waning.
- No information from brain imaging sufficiently explaining EEG pattern (e.g., brain stem hemorrhage)
- No metabolic/toxicological derangement sufficiently explaining EEG pattern (e.g., acute renal or liver failure)

M. Leitinger et al. Epilepsy & Behavior (2015)

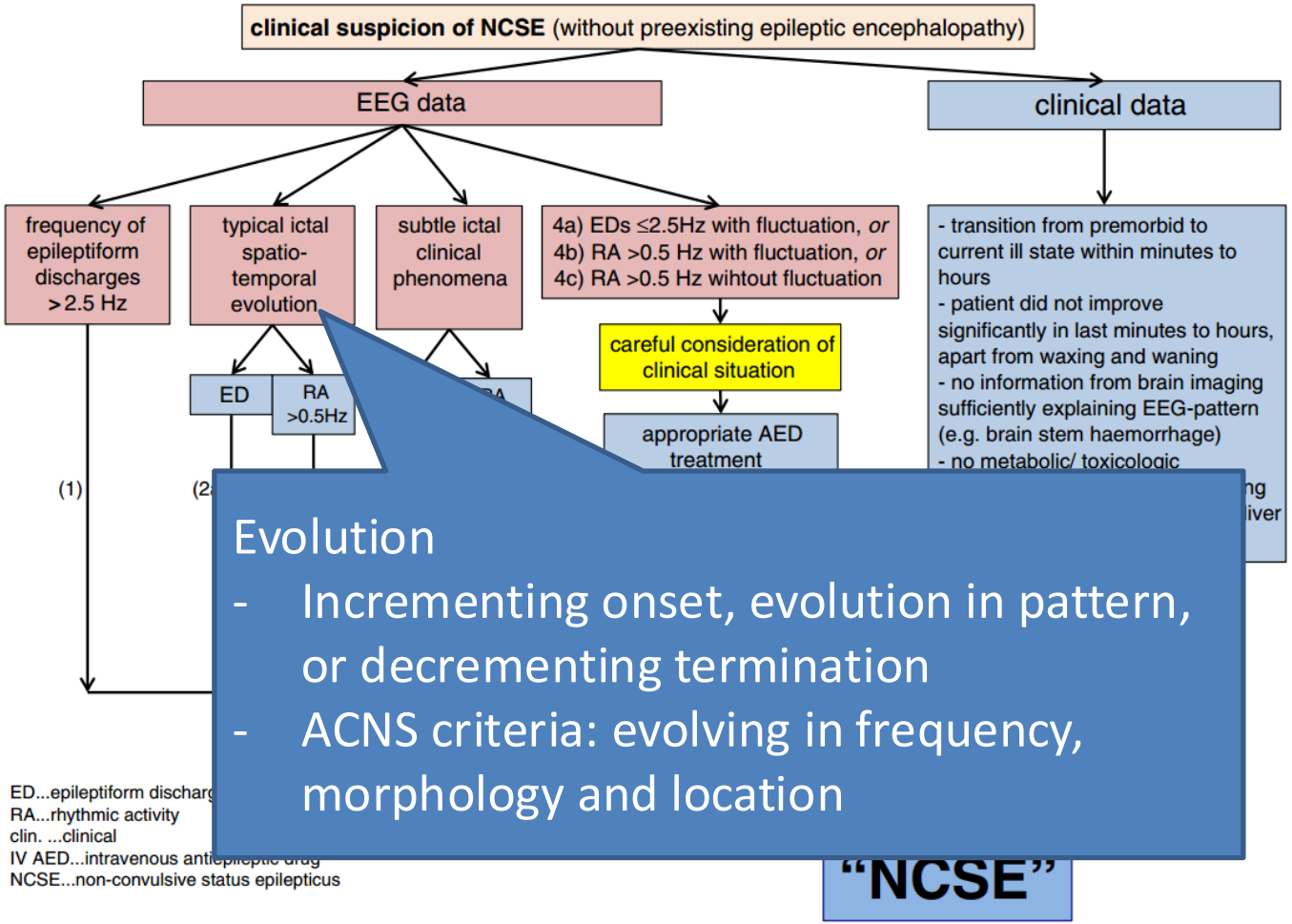


Sens 97.7%, Spec 89.6%, overall accuracy 92.5%

Leitinger M, et al. Lancet Neurol 2016; 15: 1054–62



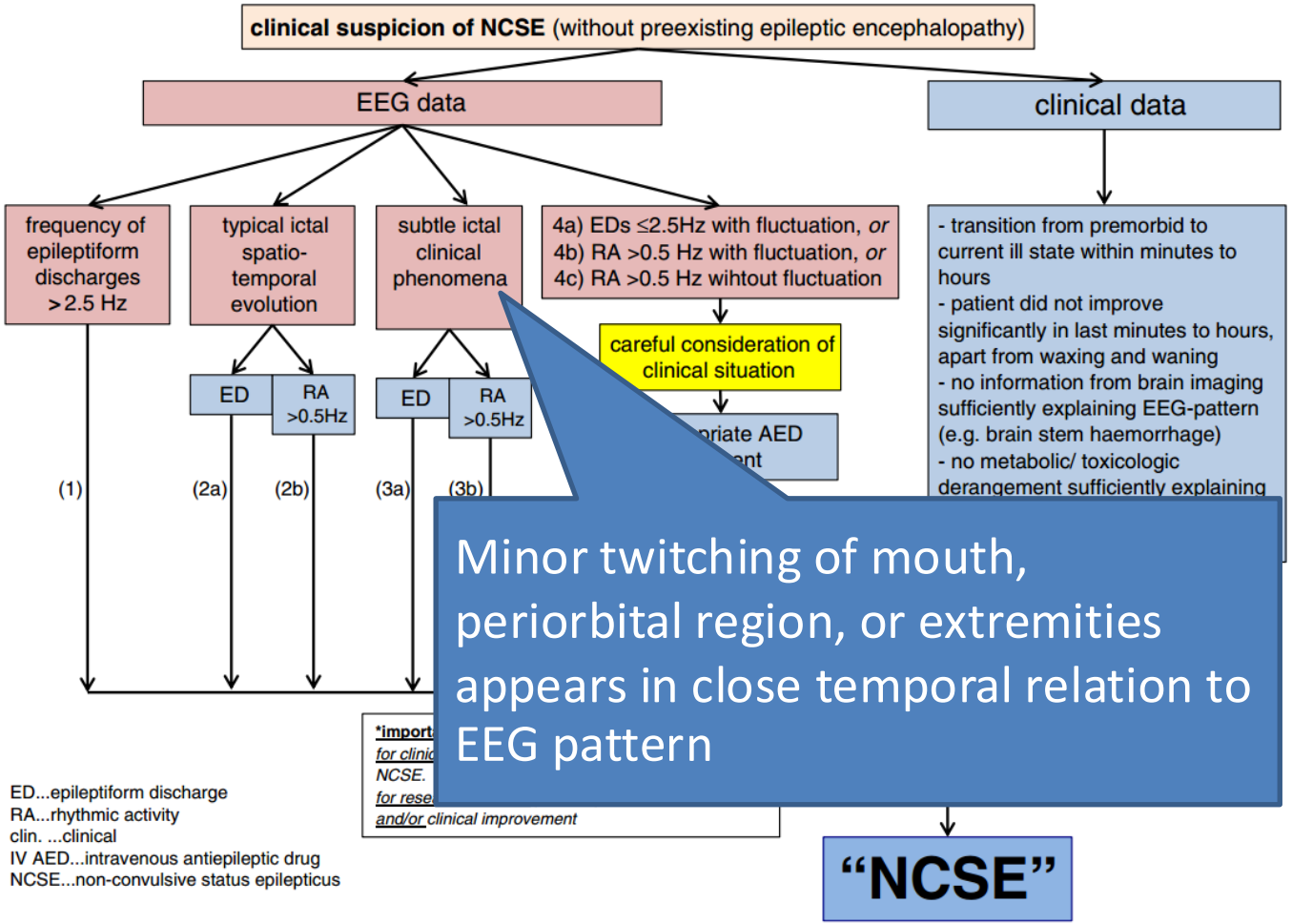
Trinka U and Leitinger M; Epilepsy & Behav2015



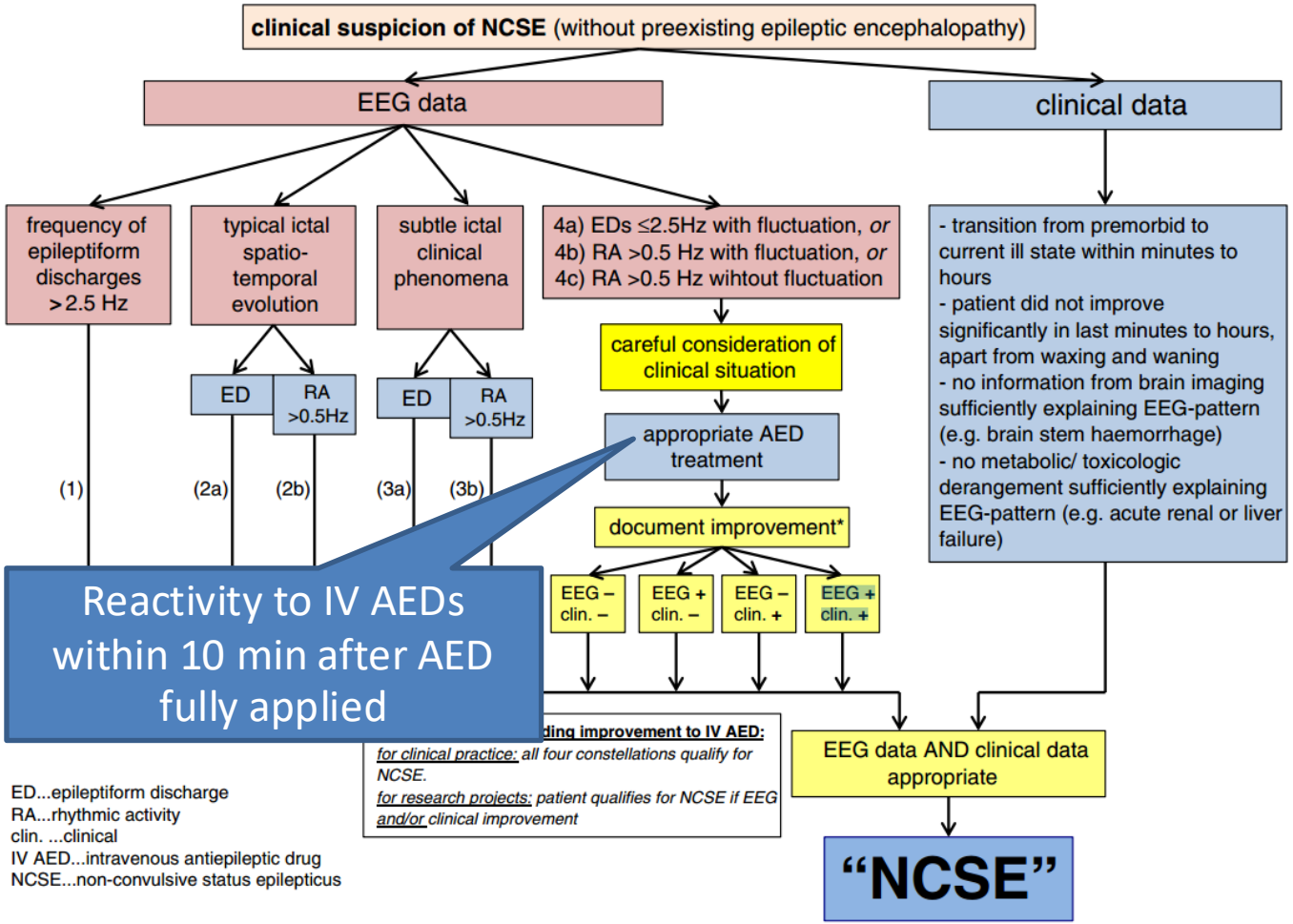
Evolution

- Incrementing onset, evolution in pattern, or decrementing termination
- ACNS criteria: evolving in frequency, morphology and location

Trinka U and Leitinger M; Epilepsy & Behav2015

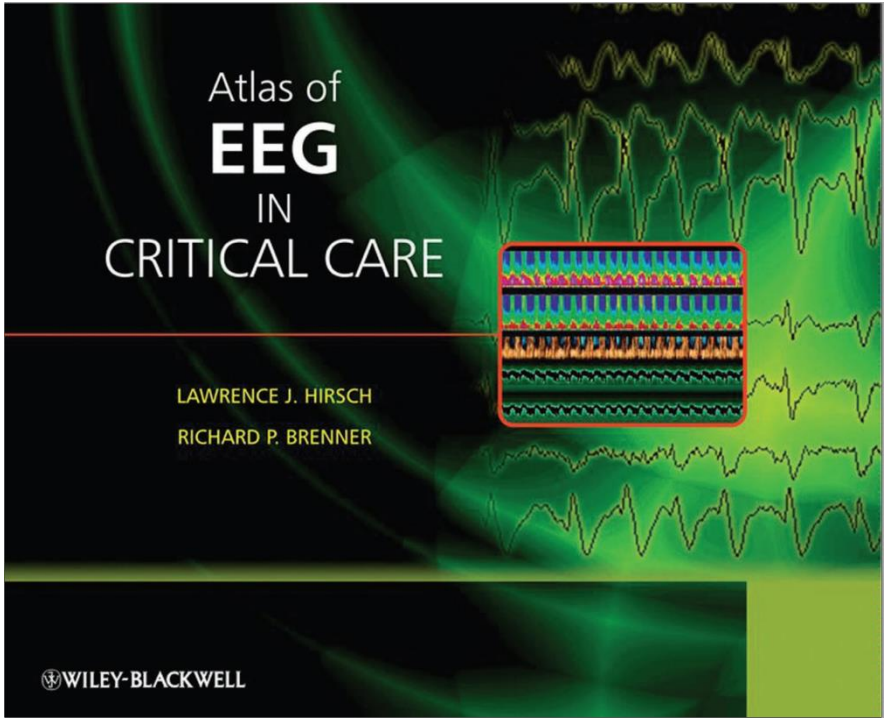


Trinka U and Leitinger M; Epilepsy & Behav2015

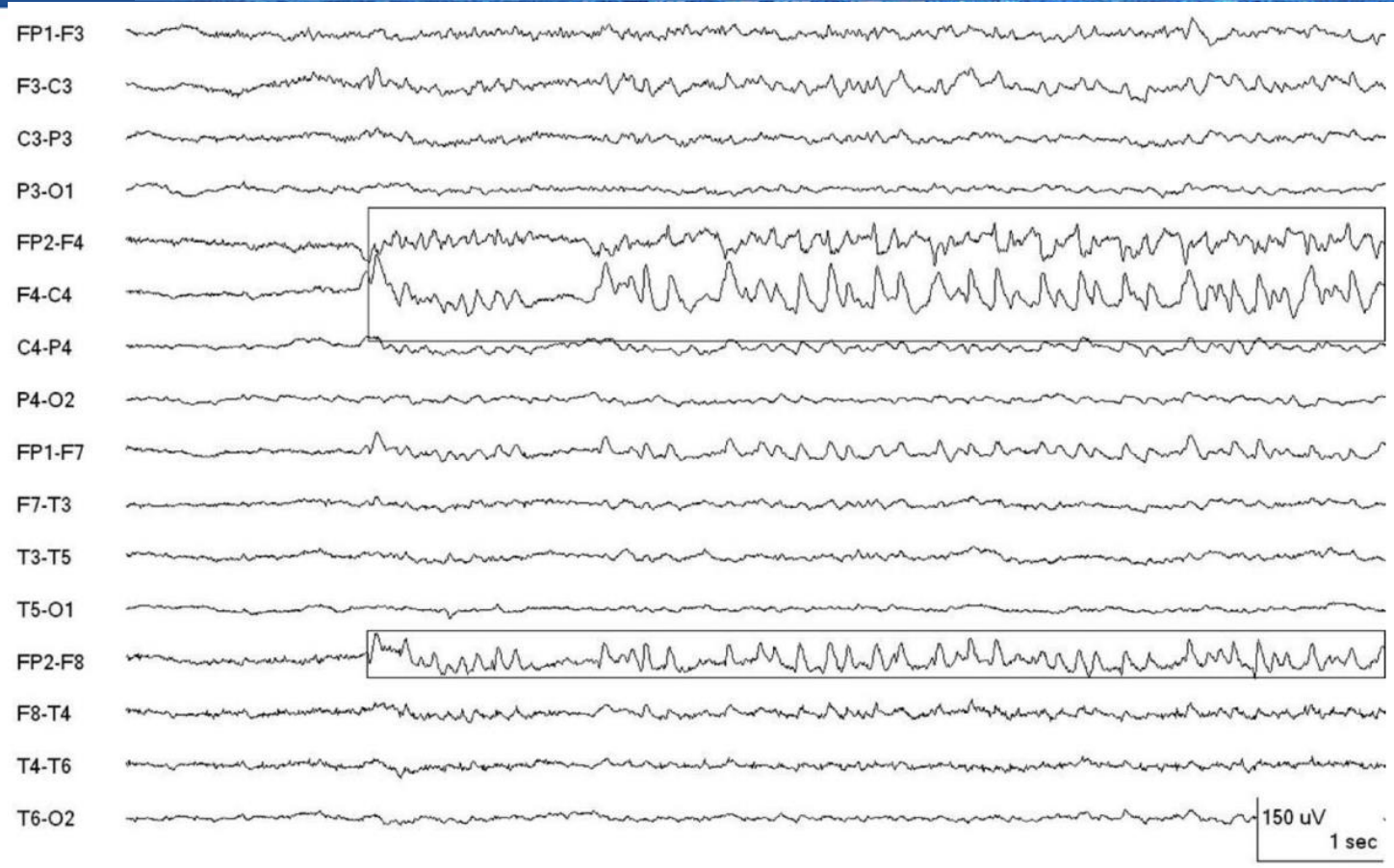


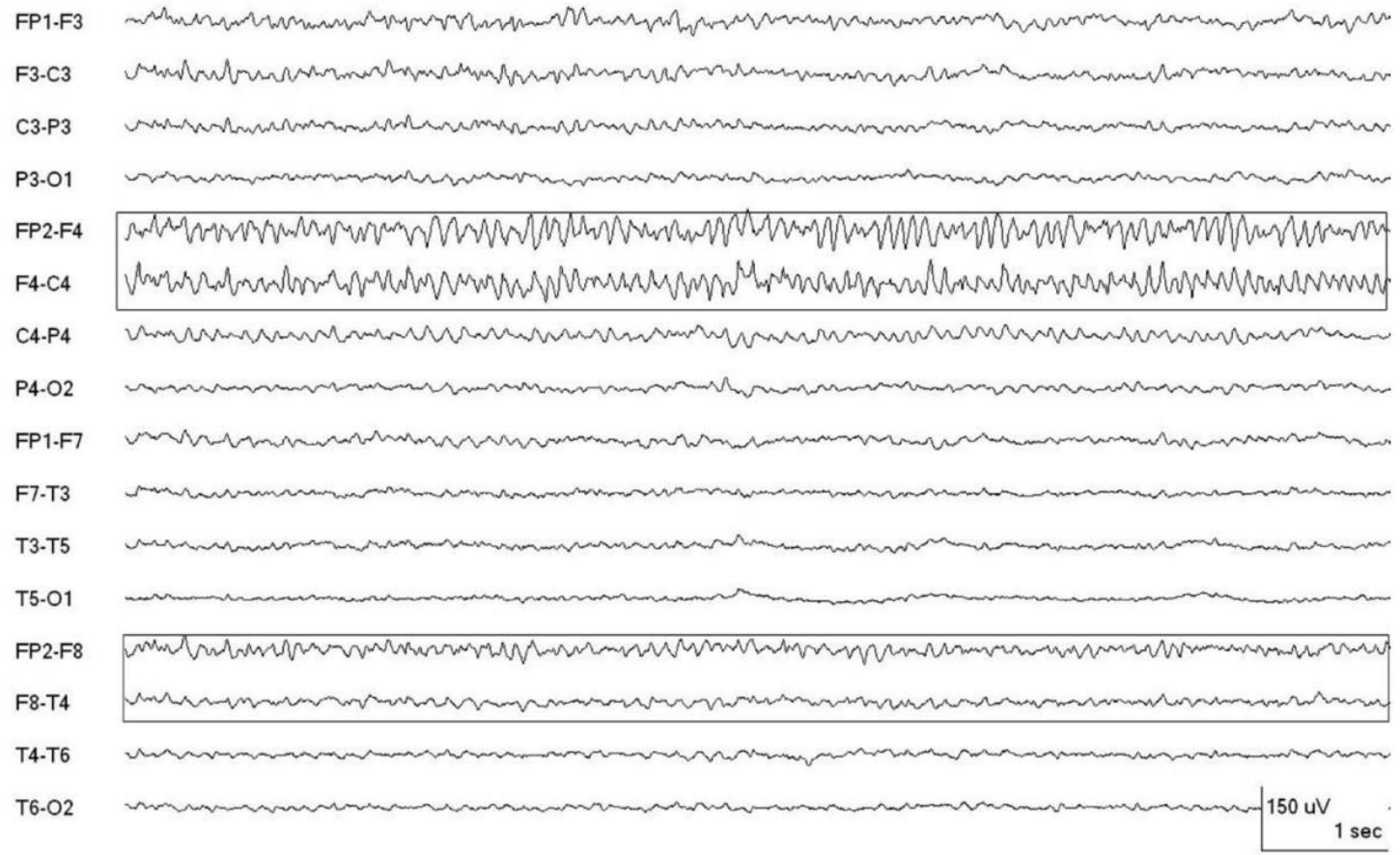
Trinka U and Leitinger M; Epilepsy & Behav2015

Reference: EEG examples from

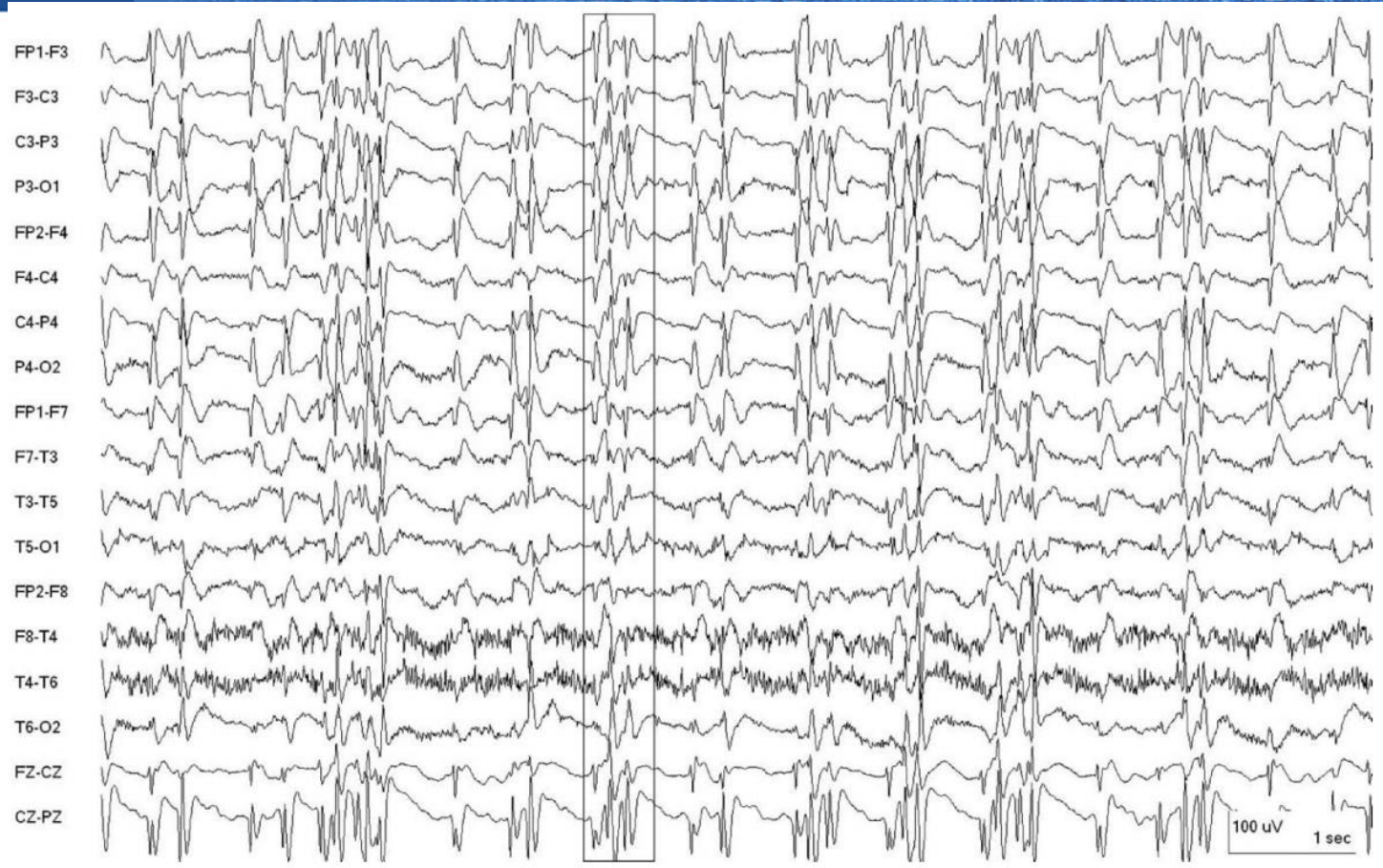


Focal SE


FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
150 uV
1 sec


FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
150 uV
1 sec

NCSE


FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
FZ-CZ
CZ-PZ
100 uV
1 sec

ACNS GUIDELINE

American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2021 Version

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Hirsch LJ, et al. J Clin Neurophysiol 2021;38: 1–29

ACNS Critical Care EEG Terminology Training Module 2021, Part 3 of 3

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D. Electrographic and Electroclinical Seizures

ELECTROGRAPHIC AND ELECTROCLINICAL SEIZURES

D. Electrographic and Electroclinical Seizures

Electrographic Seizure (ESz)

Either:

A) Epileptiform discharges averaging >2.5 Hz for ≥10 s (>25 discharges in 10 s), OR

B) Any pattern with definite evolution and lasting ≥10 s

Electroclinical Seizure (ECSz)

Any EEG pattern with either:

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

B) EEG *and* clinical improvement with a parenteral anti-seizure medication

Electrographic Status Epilepticus (ESE)

An electrographic seizure for either:

A) ≥10 continuous minutes, OR

B) A total duration of ≥20% of any 60-minute period of recording.

Electroclinical Status Epilepticus (ECSE)

An electroclinical seizure for either

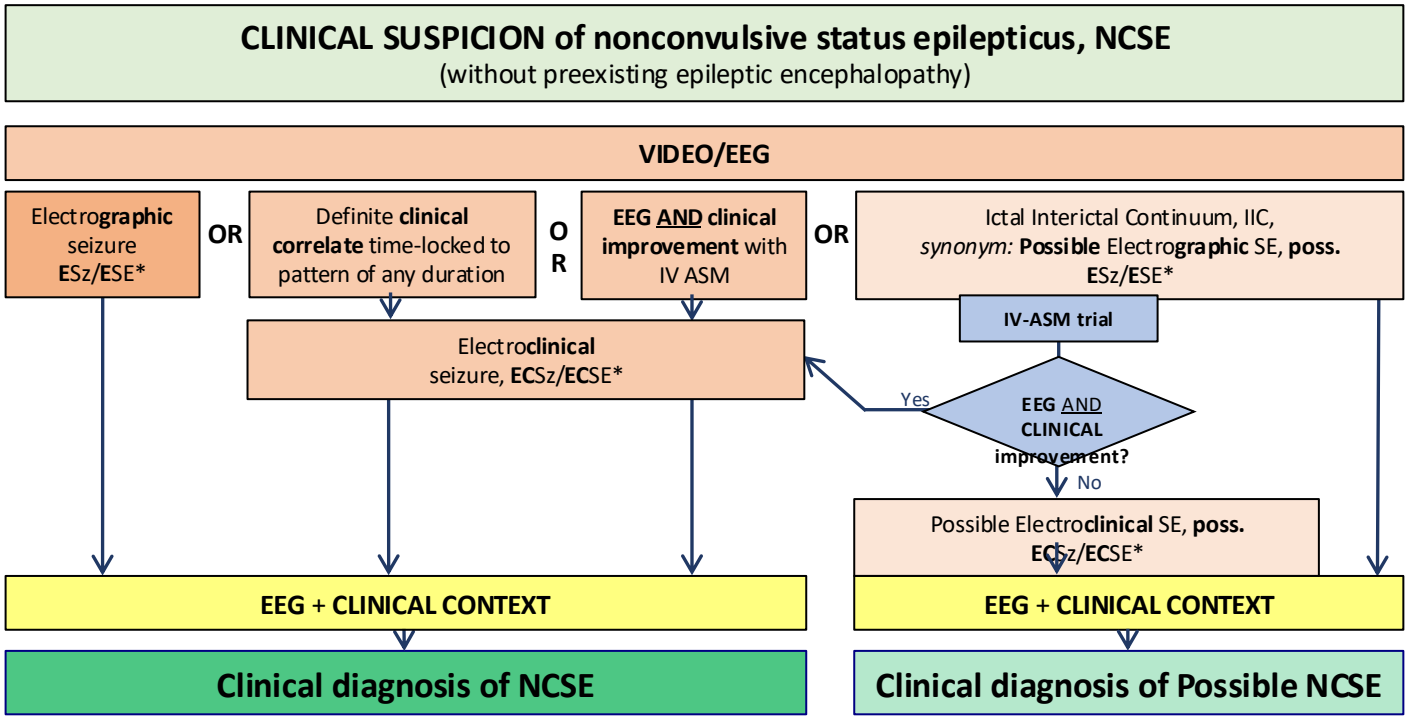
A) ≥10 continuous minutes, OR

B) A total duration of ≥20% of any 60-minute period of recording, OR

C) ≥5 continuous minutes if the seizure is convulsive (i.e., with bilateral tonic-clonic motor activity).

Possible ECSE: An RPP that qualifies for the IIC (below) that is present for ≥10 continuous minutes or for a total duration of ≥20% of any 60-minute period of recording, which shows EEG improvement with a parenteral anti-seizure medication ***BUT*** without clinical improvement.

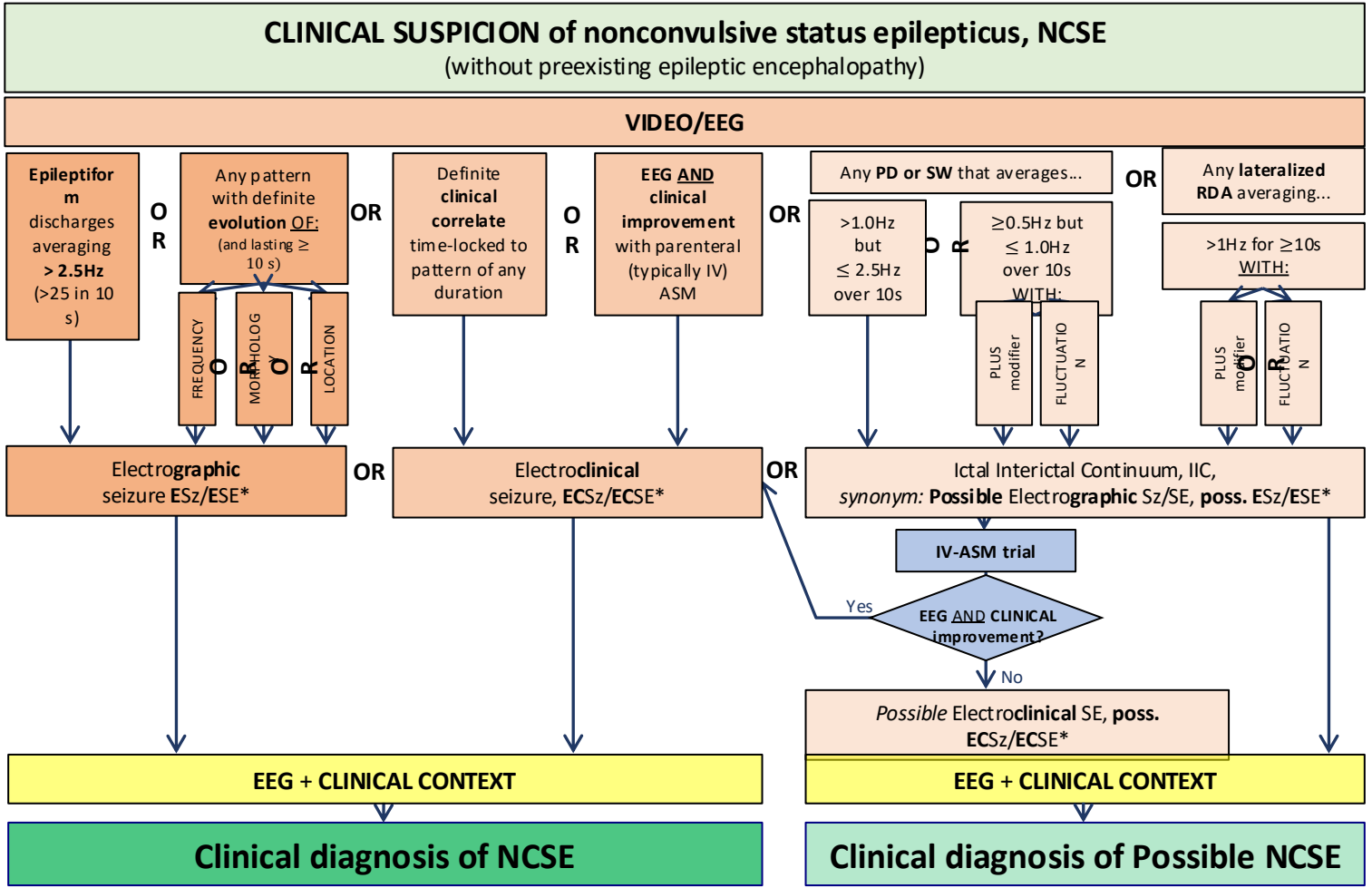
Slides from ACNS Critical Care EEG Terminology Training Module 2021



* Status epilepticus if ≥10 continuous minutes OR ≥ 20% of any hour; seizure if neither is true

IV-ASM Intravenous Anti-Seizure Medication; PD Periodic Discharge; RDA Rhythmic Delta Activity; SW Spike-and-wave or sharp-and-wave

Modified from Trinka & Leitinger, 2022, submitted



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IV-ASM Intravenous Anti-Seizure Medication; PD Periodic Discharge; RDA Rhythmic Delta Activity; SW Spike-and-wave or sharp-and-wave

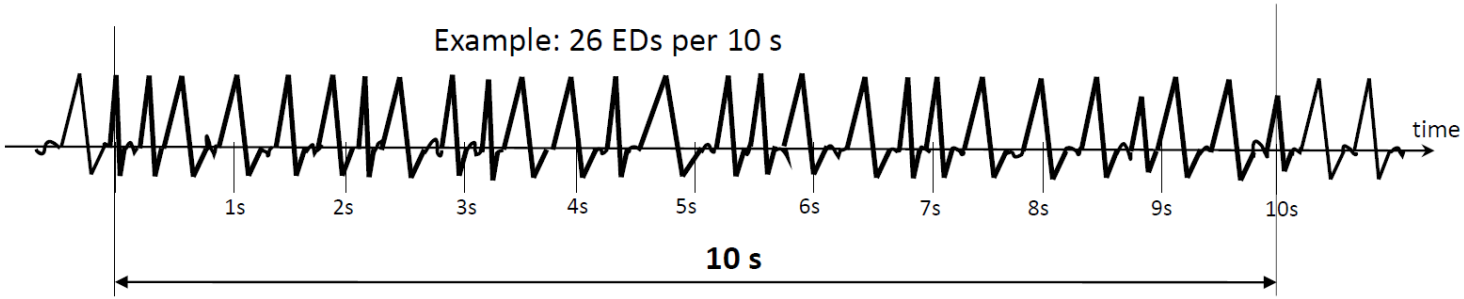
Modified from Trinka & Leitinger, 2022, submitted

Electrographic and Electroclinical Seizures

Electrographic Seizure (ESz)
Either: A) Epileptiform discharges averaging >2.5 Hz for ≥10 s (>25 discharges in 10 s), OR B) Any pattern with definite evolution and lasting ≥10 s

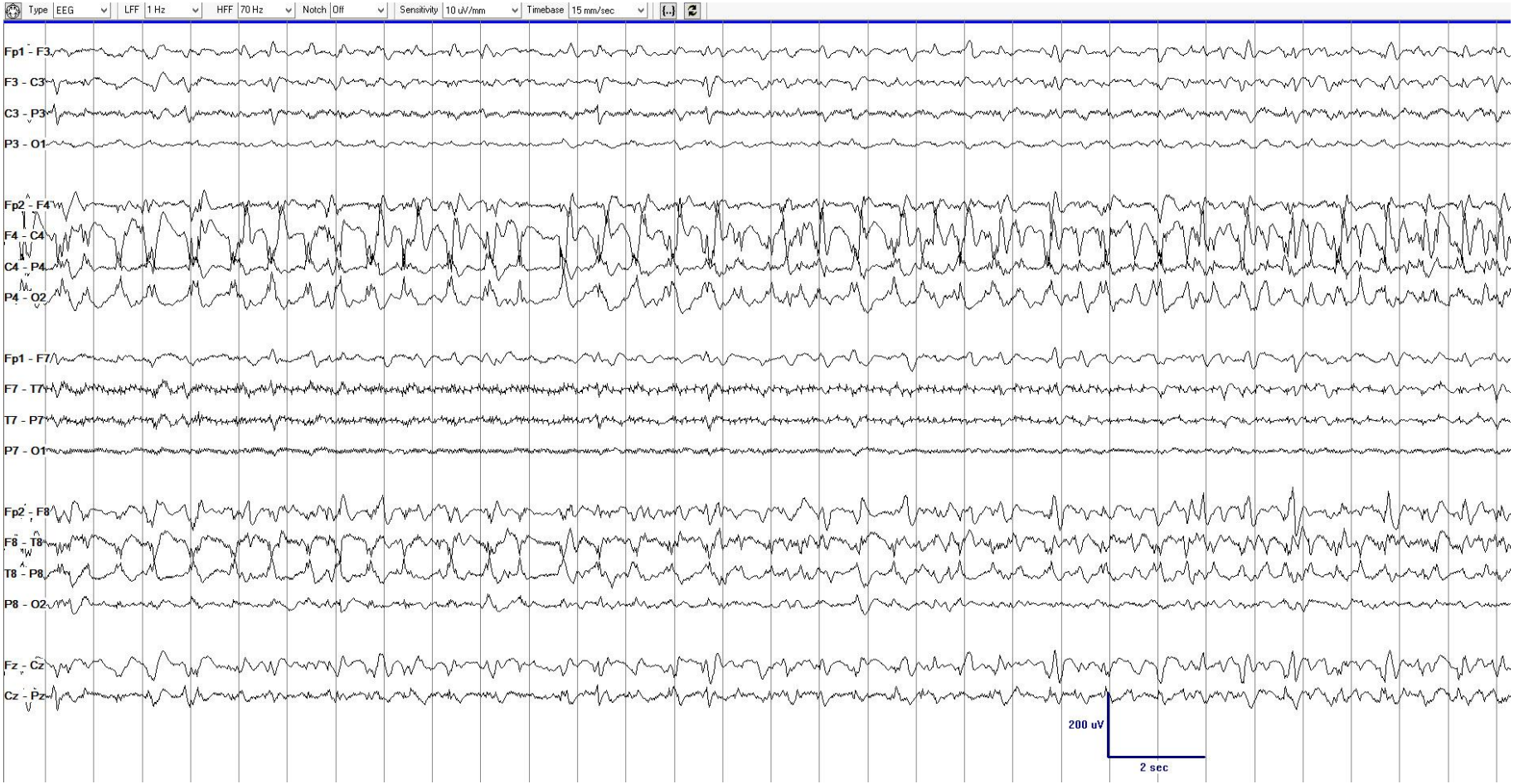
Electrographic seizure (ESz):

Epileptiform discharges **>2.5 Hz** for **≥10 s** (>25 ED in 10s)

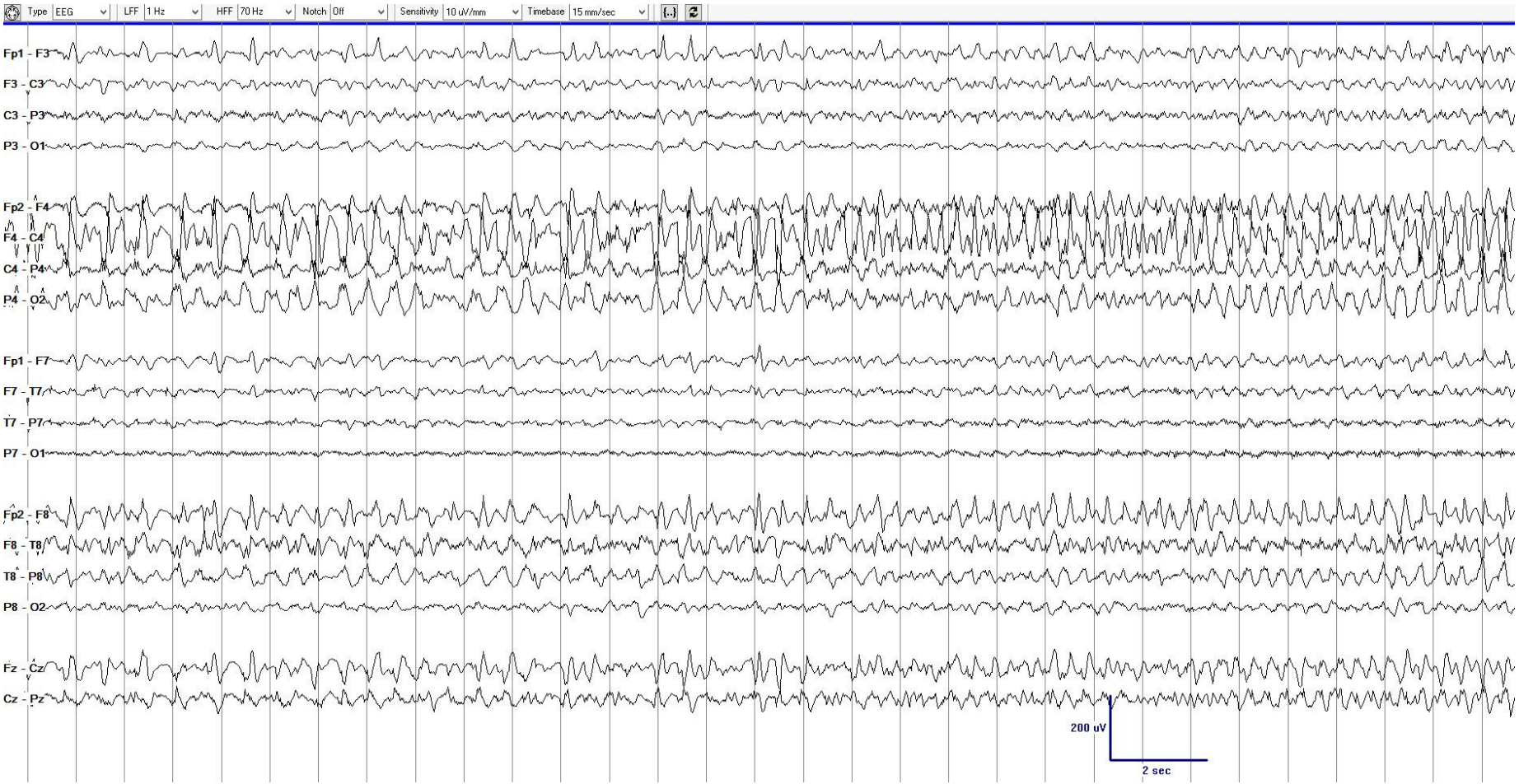


OR

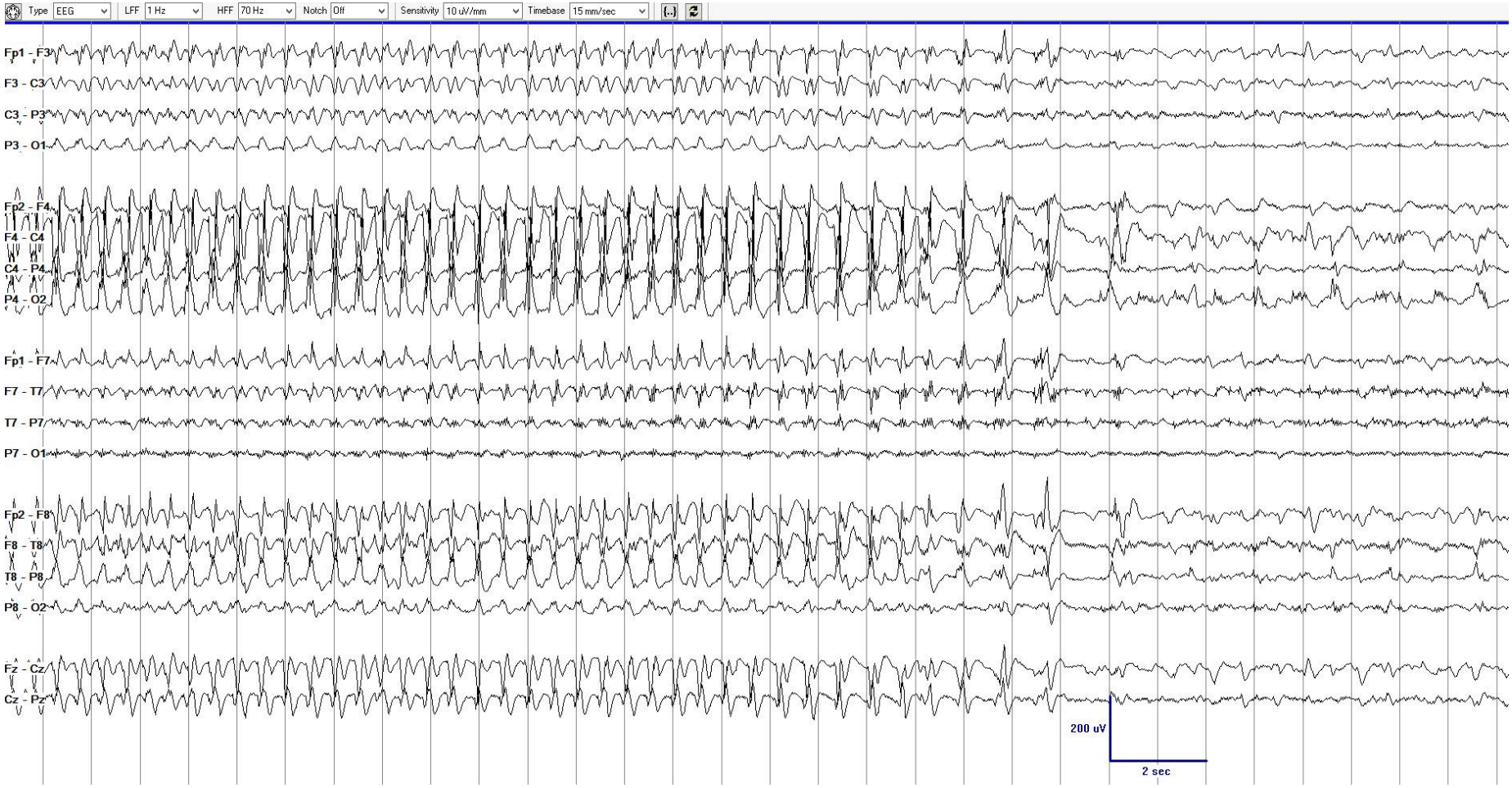
Any pattern with definite evolution lasting ≥10 s



How would you best describe the 3 pages of EEG (compressed time scale), page 1 of 3

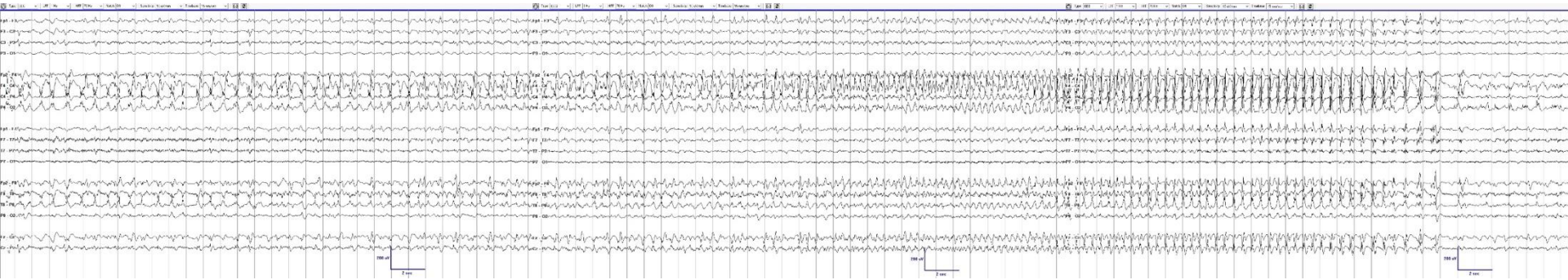


How would you best describe the 3 pages of EEG (compressed time scale), page 2 of 3



How would you best describe the 3 pages of EEG (compressed time scale), page 3 of 3

Page 1 Page 2 Page 3



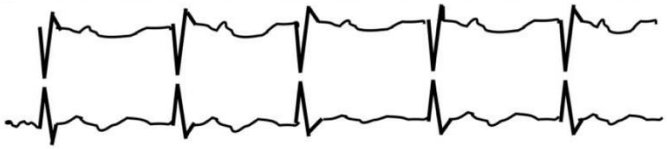
Electrographic seizure (ESz) with clear evolution in frequency, morphology, and location lasting ≥10 seconds.
NOTE: If this pattern continued for 10 continuous minutes, OR if seizures comprised ≥20% (i.e., ≥12 minutes) of any given hour, this would also qualify as electrographic status epilepticus (ESE).

Electroclinical Seizures

Electroclinical Seizure (ECSz)
Any EEG pattern with either: A) Definite clinical correlate time-locked to the pattern (of any duration), OR B) EEG *and* clinical improvement with a parenteral anti-seizure medication

Any EEG pattern with either:

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



time-locked clinical correlate, e.g., jerk

time-locked clinical correlate, e.g., jerk

time-locked clinical correlate, e.g., jerk

time-locked clinical correlate, e.g., jerk

time-locked clinical correlate, e.g., jerk

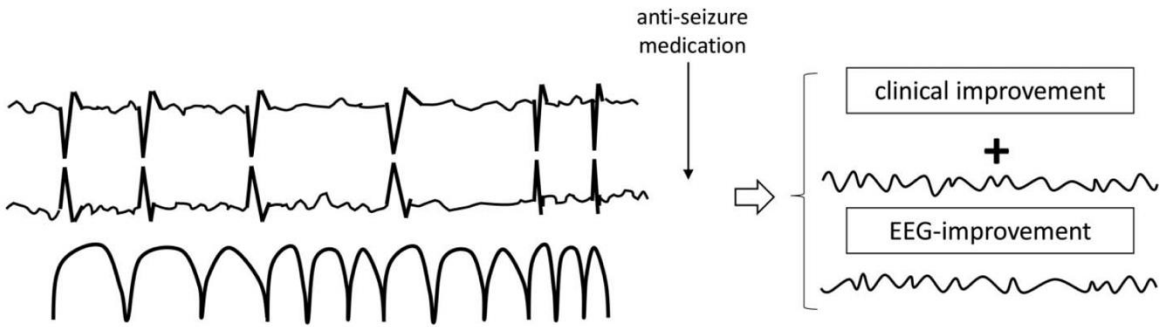
time-locked clinical correlate, e.g., jerk

time-locked clinical correlate, e.g., jerk

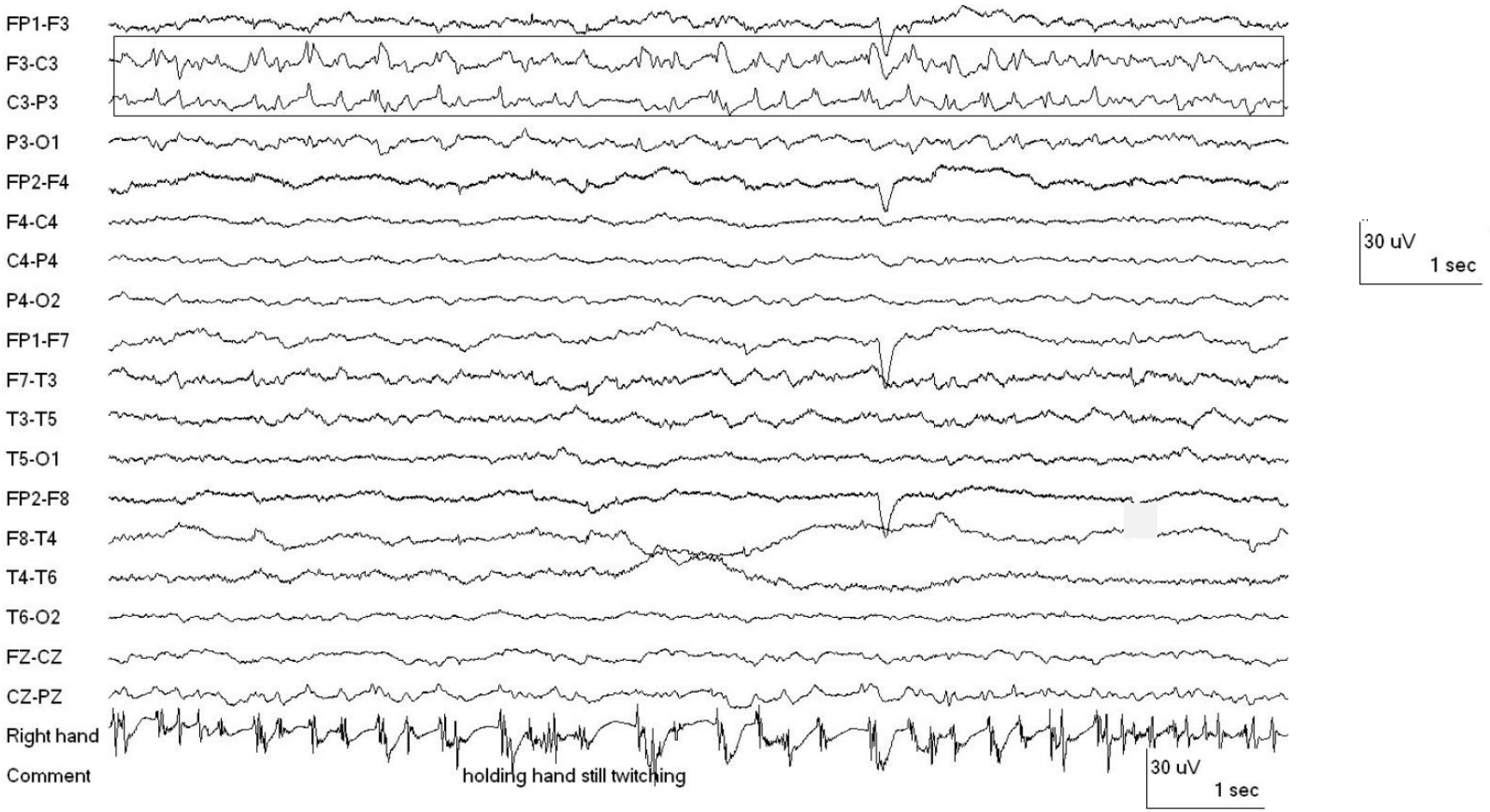
time-locked clinical correlate, e.g., jerk

OR

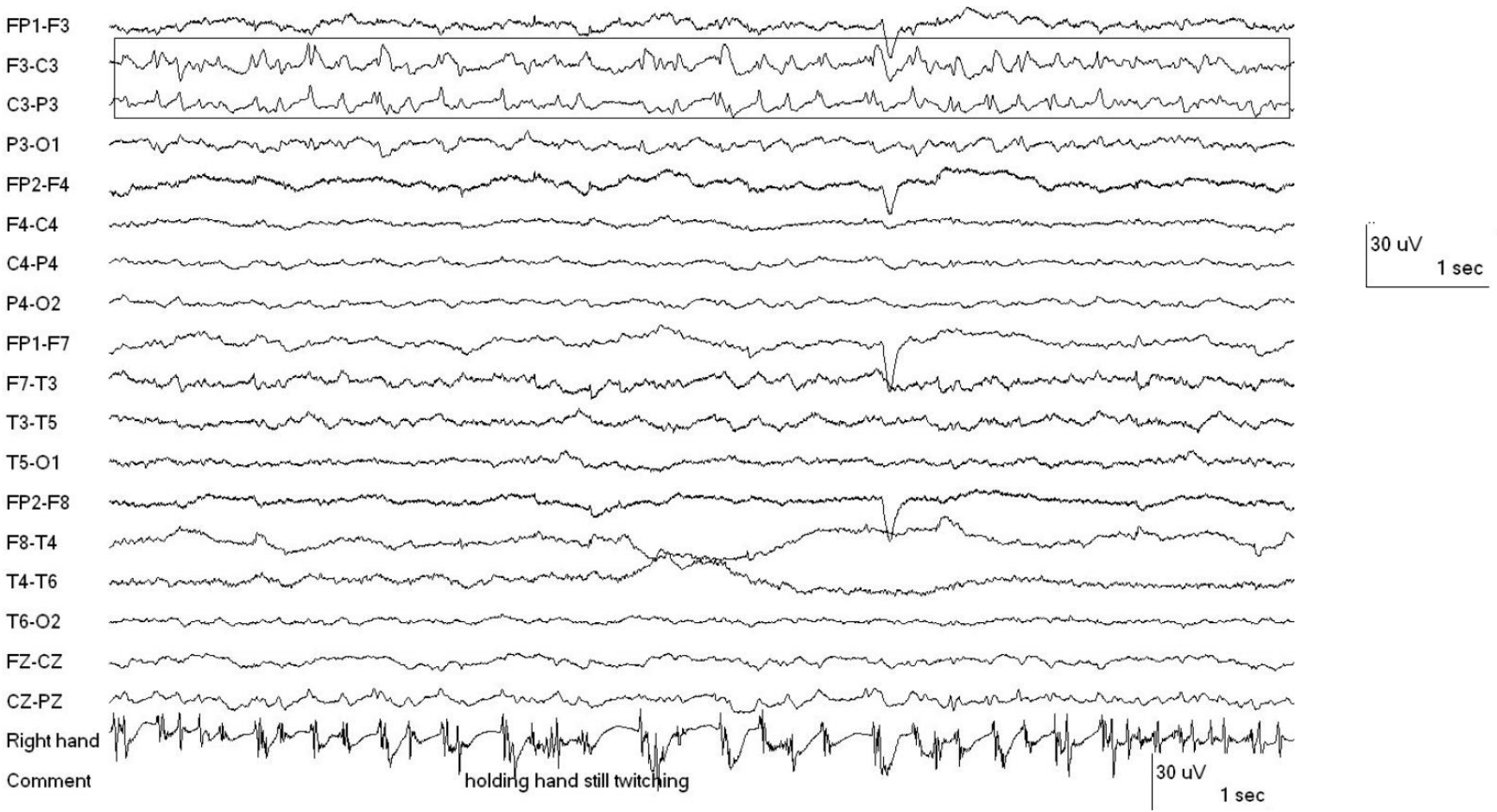
EEG ***AND*** clinical improvement with a parenteral (typically IV) anti-seizure medication



Slides from ACNS Critical Care EEG Terminology Training Module 2021

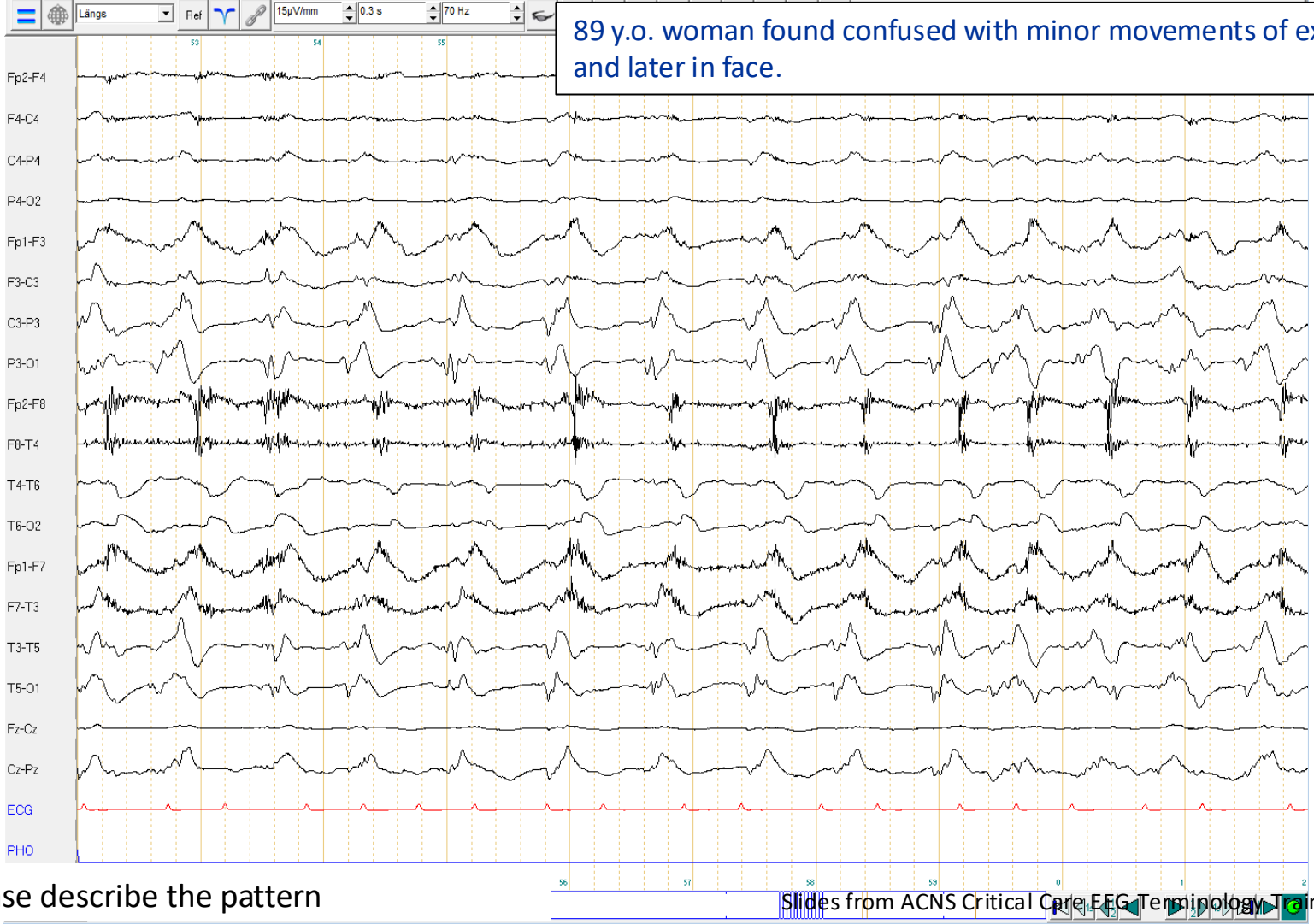


What is the correct term for this pattern?

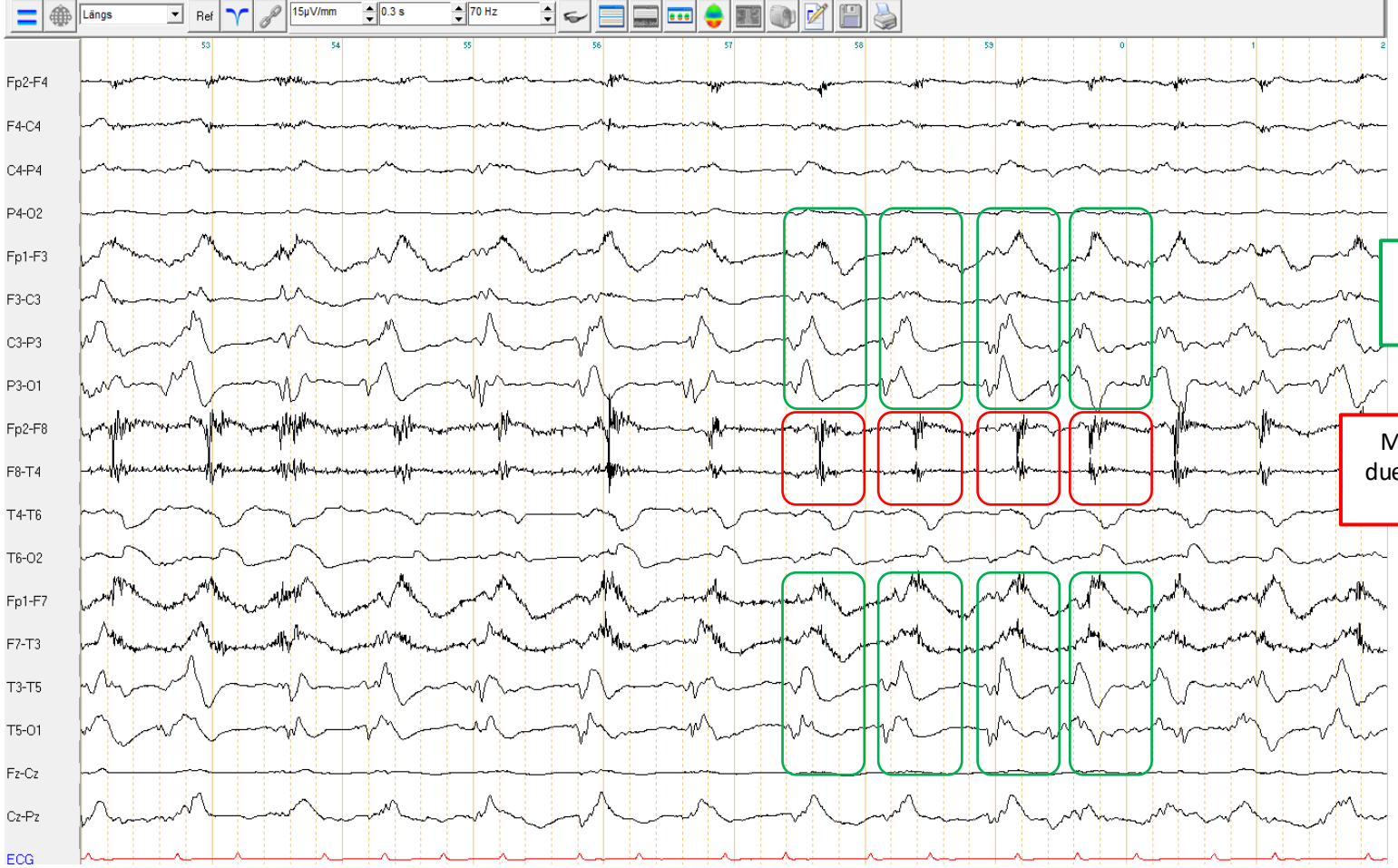


Lateralized Periodic Discharges time locked with contralateral motor semiology (see bottom channel); thus, this is an *Electroclinical seizure* or *Electroclinical status epilepticus* (depending on time criterion)

89 y.o. woman found confused with minor movements of extremities and later in face.



Please describe the pattern



Lateralized Periodic Discharges time locked with contralateral motor semiology; thus, this is an *Electroclinical seizure* or *Electroclinical status epilepticus* (depending on time criterion)

E. Brief potentially Ictal Rhythmic Discharges (BIRDs)

BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES (BIRDs)

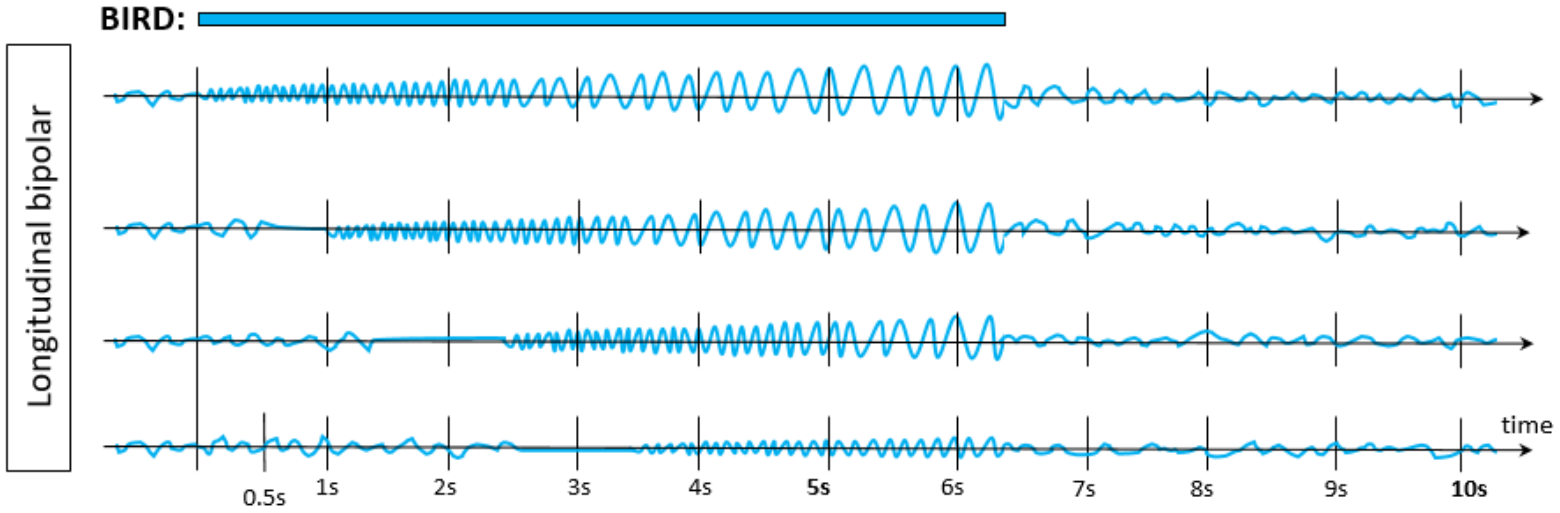
E. Brief Potentially Ictal Rhythmic Discharges (BIRDs)
Focal (including L, BI, UI or Mf) or generalized rhythmic activity >4 Hz (at least 6 waves at a regular rate) lasting ≥0.5 to <10 s, not consistent with a known normal pattern or benign variant, not part of burst-suppression or burst-attenuation, without definite clinical correlate, and that has at least one of A, B or C below:
Definite BIRDs feature either: A. Evolution ("evolving BIRDs") OR B. Similar morphology and location as interictal epileptiform discharges or seizures in the same patient
Possible BIRDs are C. Sharply contoured but without (a) or (b) above

Slides from ACNS Critical Care EEG Terminology Training Module 2021

BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES

Brief Potentially Ictal Rhythmic Discharges (BIRDs):

a. DEFINITE BIRDs: Evolution ("evolving BIRDs").

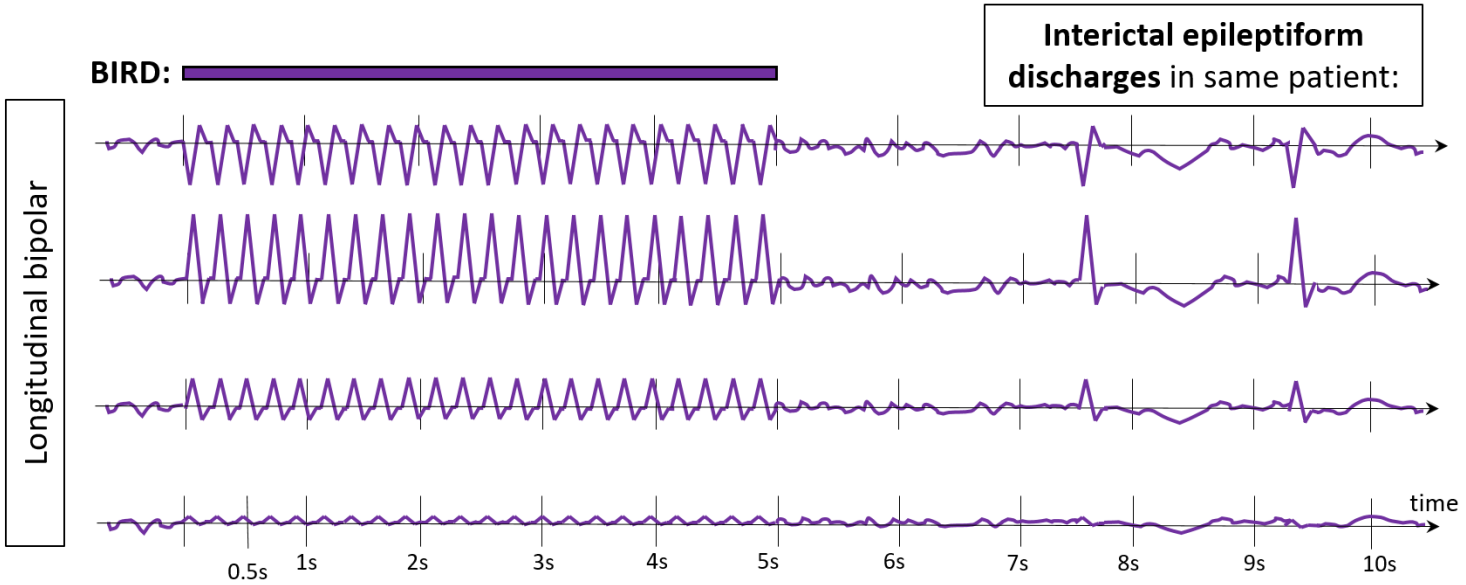


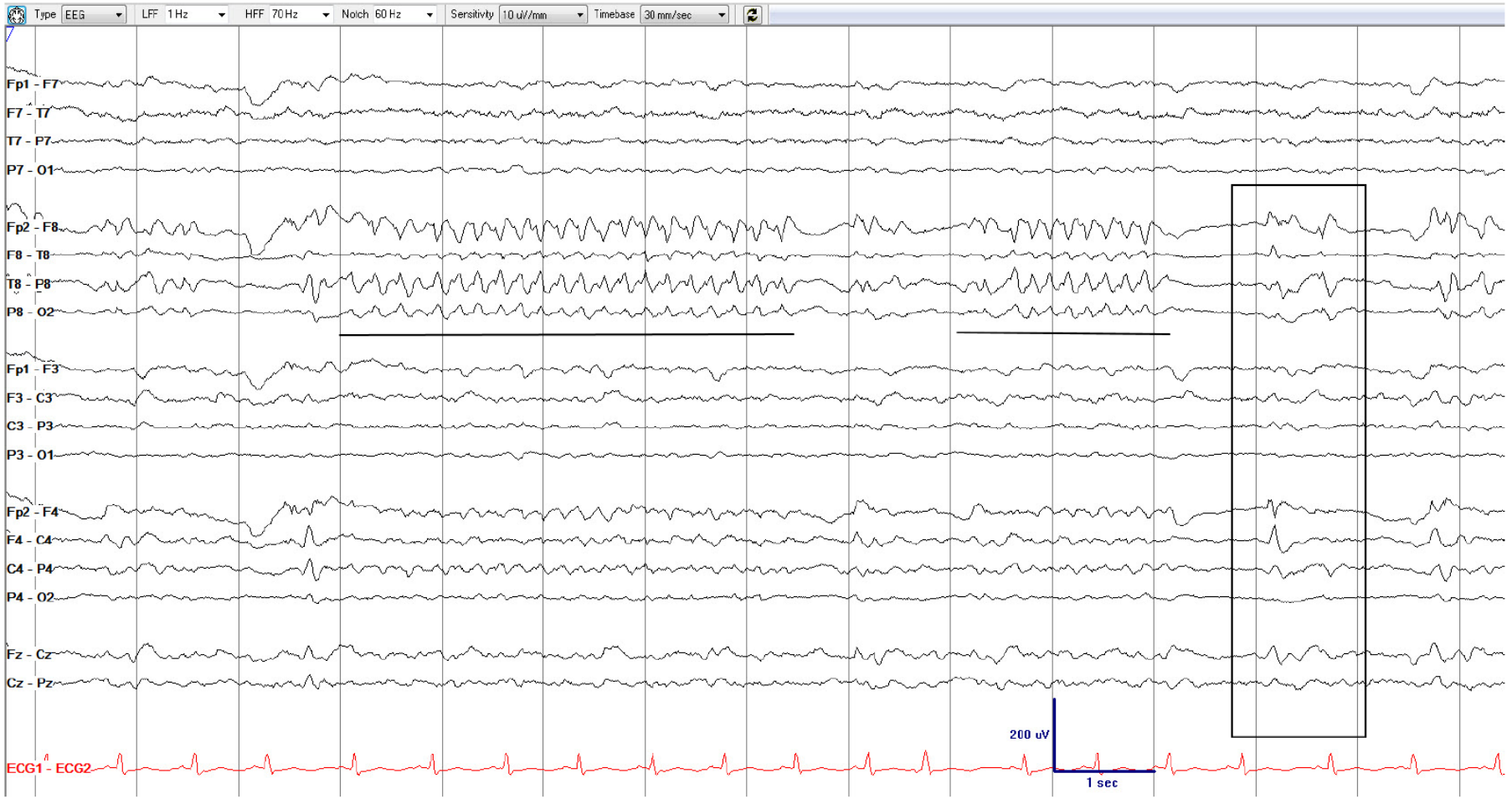
OR…

BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES

Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. DEFINITE BIRDs: Similar morphology and location as <u>interictal epileptiform discharges</u> in the same patient.





How would you describe the underlined patterns?

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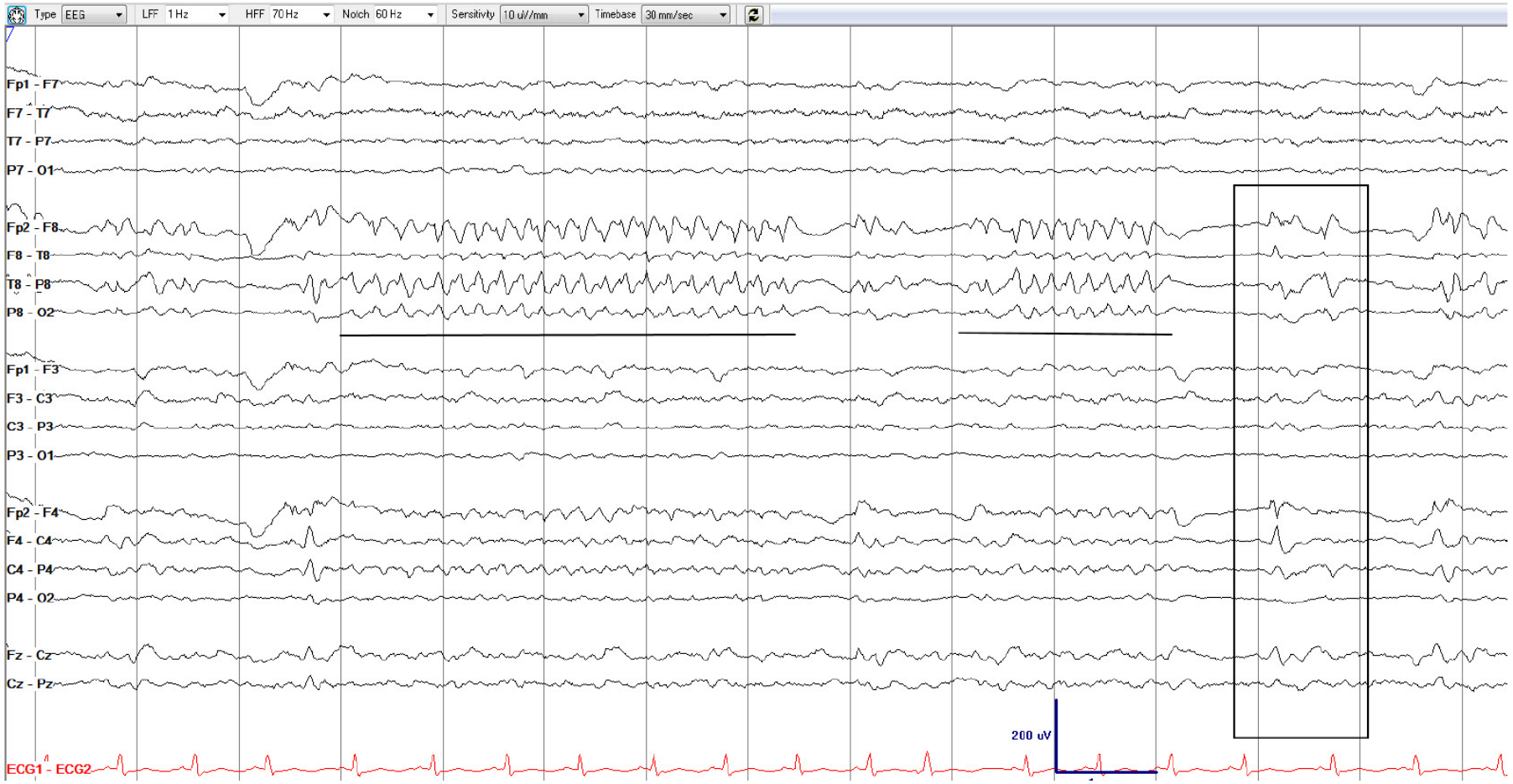

Brief Potentially Ictal Rhythmic Discharges, similar to sporadic epileptiform discharges = DEFINITE BIRDs

(Right anterior-mid temporal maximum, 5 Hz, sharply contoured, rhythmic activity, lasting 4.5 and 2 seconds (underlined). This activity has a similar **location and morphology** as the sporadic epileptiform discharges (box), making this a definite BIRD.

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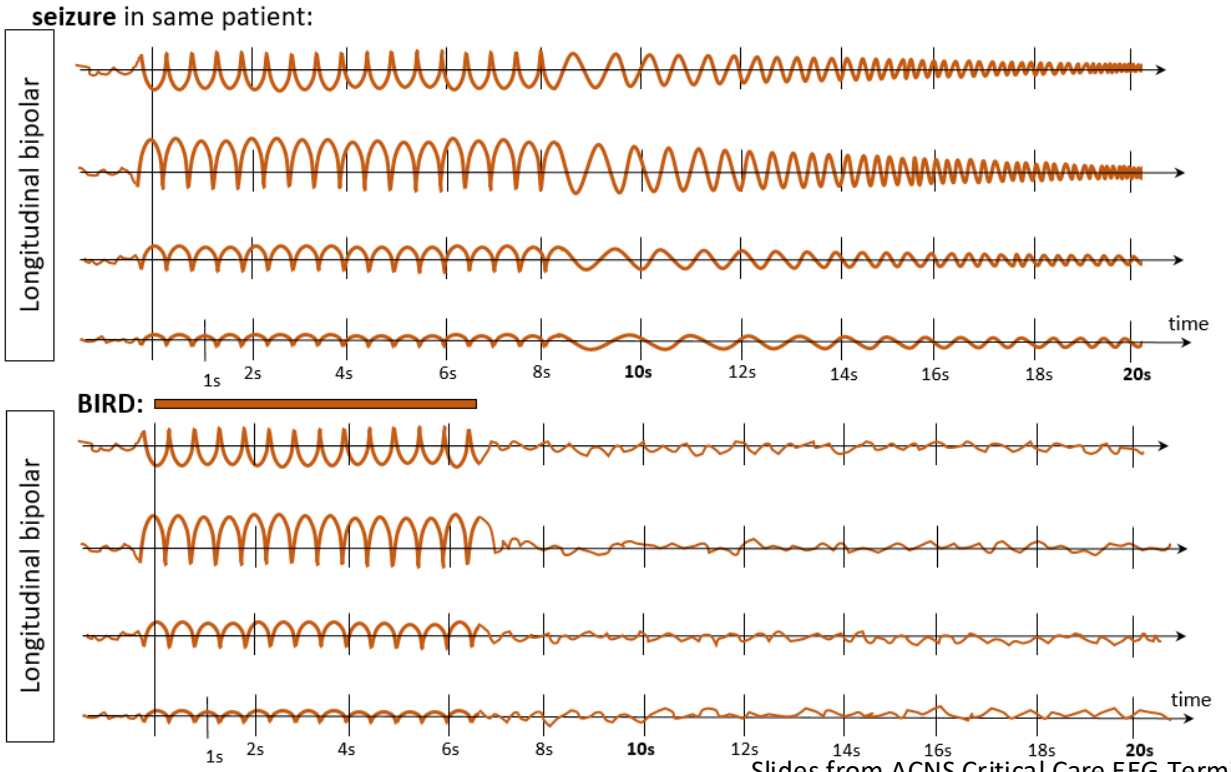
BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES

Brief Potentially Ictal Rhythmic Discharges (BIRDs):

b. DEFINITE BIRDs: Similar morphology and location as seizures in the same patient.



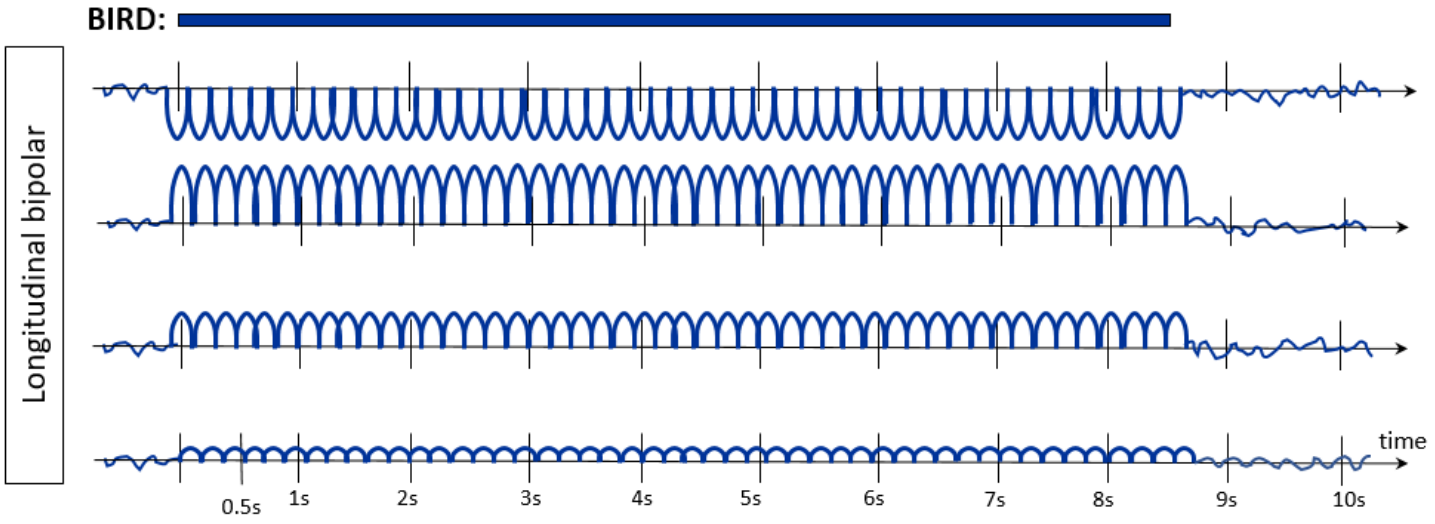
OR…

Slides from ACNS Critical Care EEG Terminology Training Module 2021

BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES

Brief Potentially Ictal Rhythmic Discharges (BIRDs):

c. POSSIBLE BIRDs: sharply contoured but without evolution and not similar morphology and location as interictal epileptiform discharges or seizures in the same patient.



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F. Ictal-Interictal Continuum (IIC)

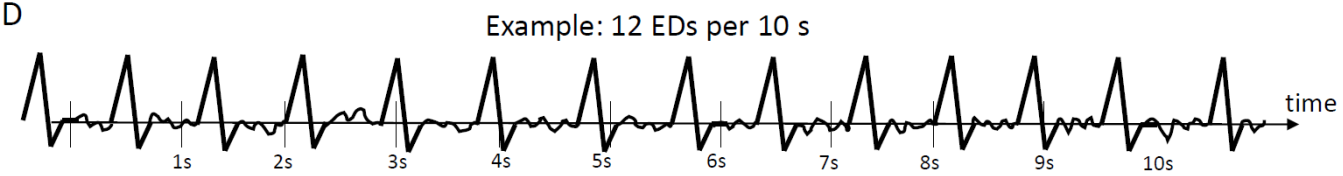
ICTAL-INTERICTAL CONTINUUM (IIC)

This term is synonymous with “possible ESz” or “possible electrographic SE.” The IIC is a purely electrographic term that is not a diagnosis; it requires careful interpretation in the full clinical context. A pattern on the IIC is a pattern that does not qualify as an ESz or ESE, but there is a reasonable chance that it may be contributing to impaired alertness, causing other clinical symptoms, and/or contributing to neuronal injury. Thus, it is potentially ictal in at least some sense and often warrants a diagnostic treatment trial, typically with a parenteral antiseizure medication.

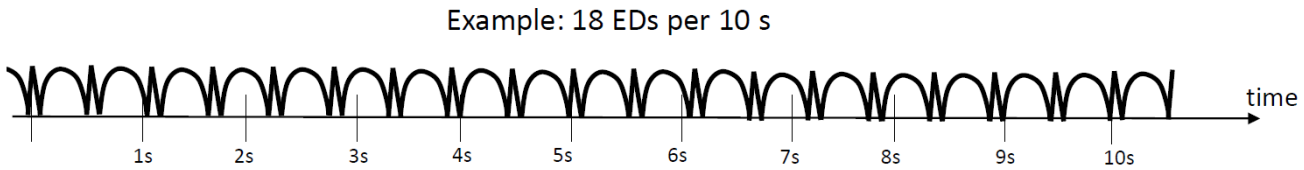
The following patterns can be considered to be on the ictal-interictal continuum (IIC):

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);

PD



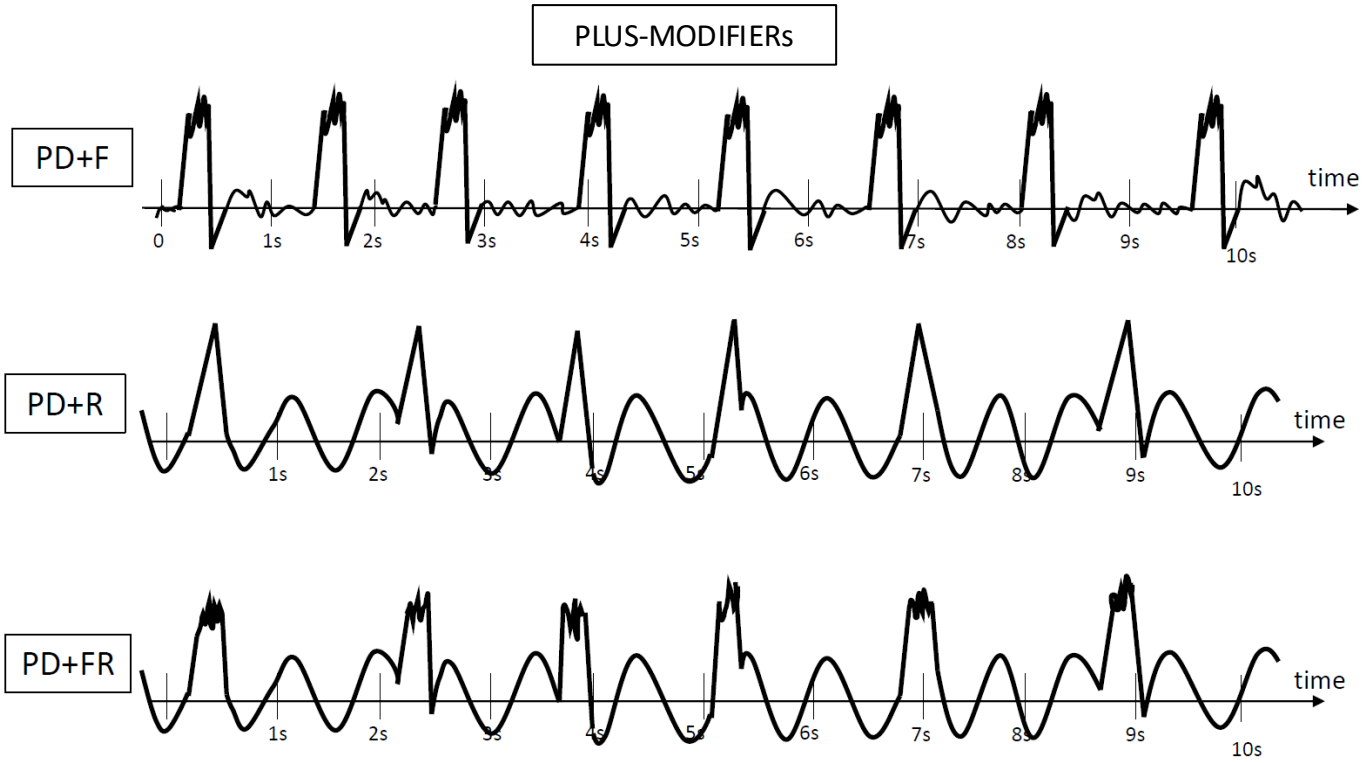
SW



OR…

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;

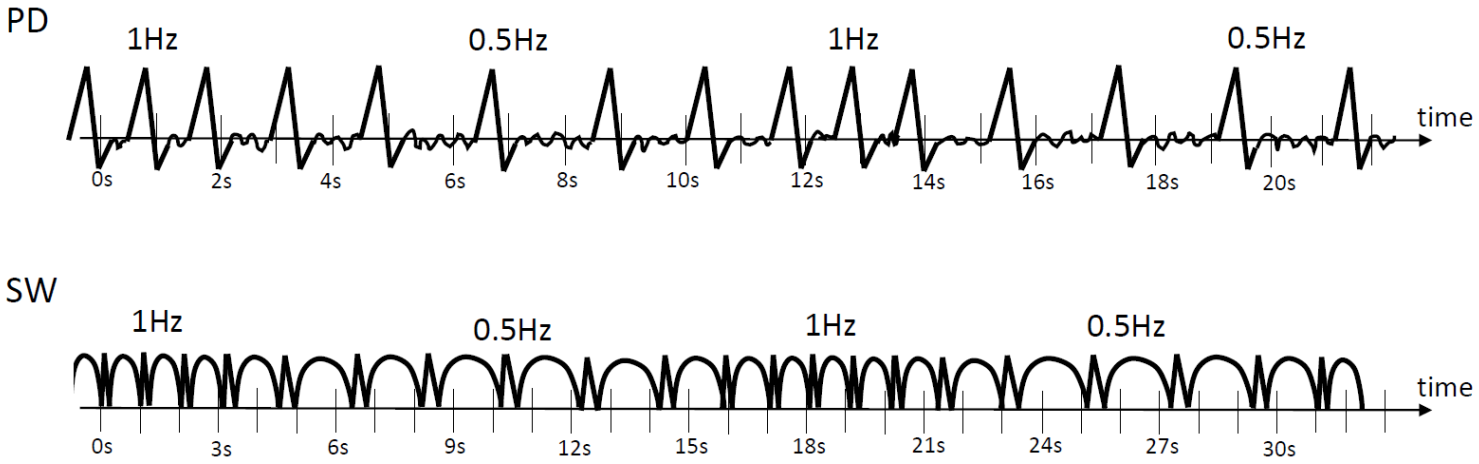


OR…

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;

FLUCTUATION

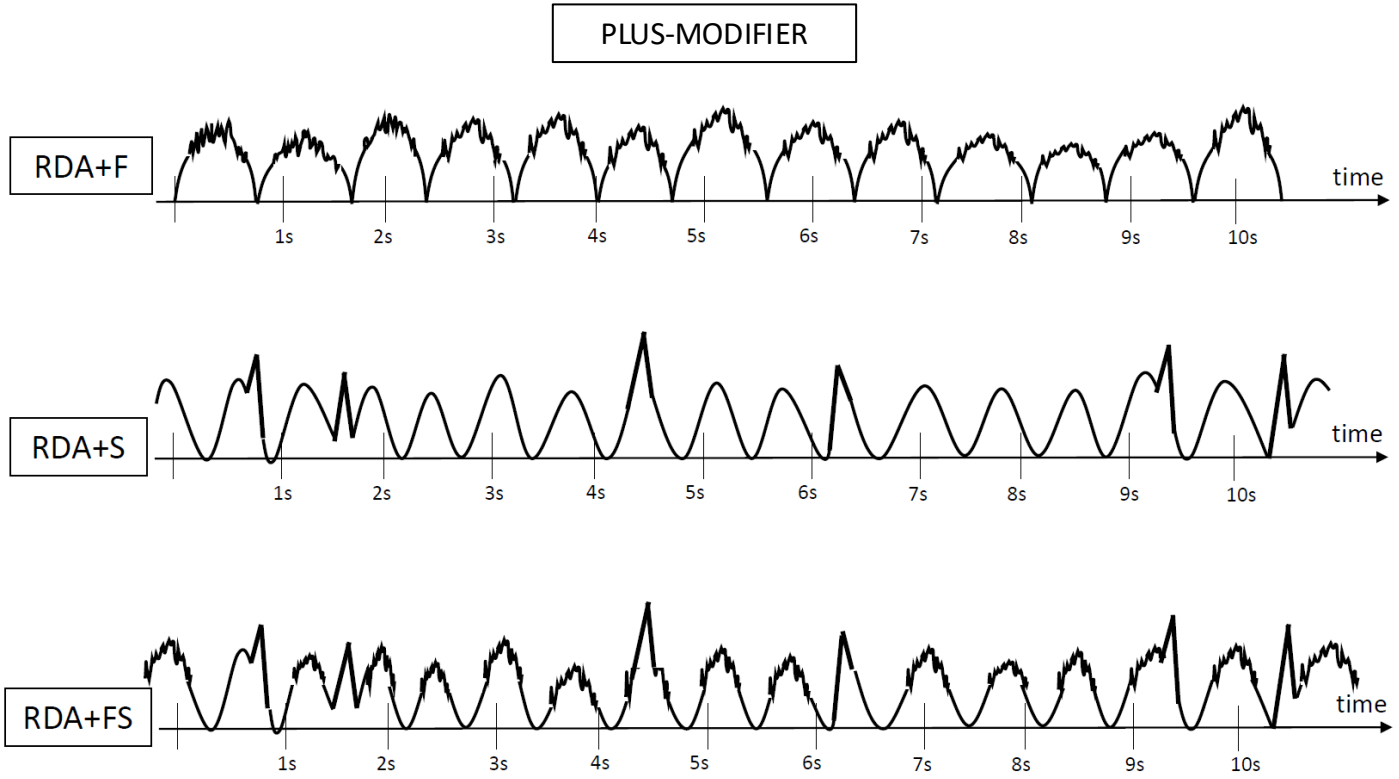


OR…

Slides from ACNS Critical Care EEG Terminology Training Module 2021

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.



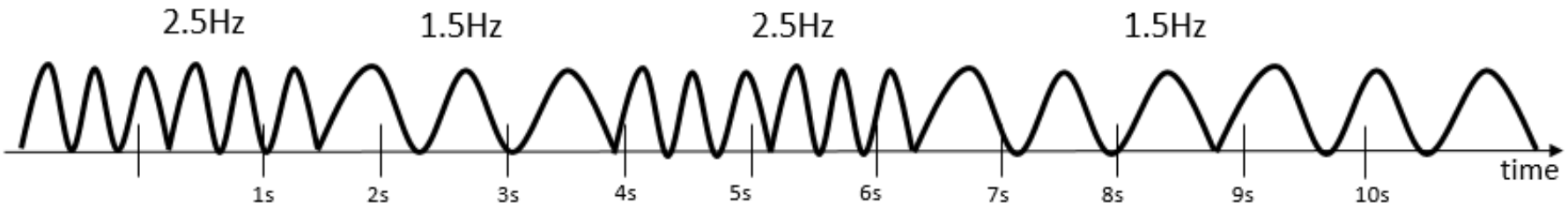
OR…

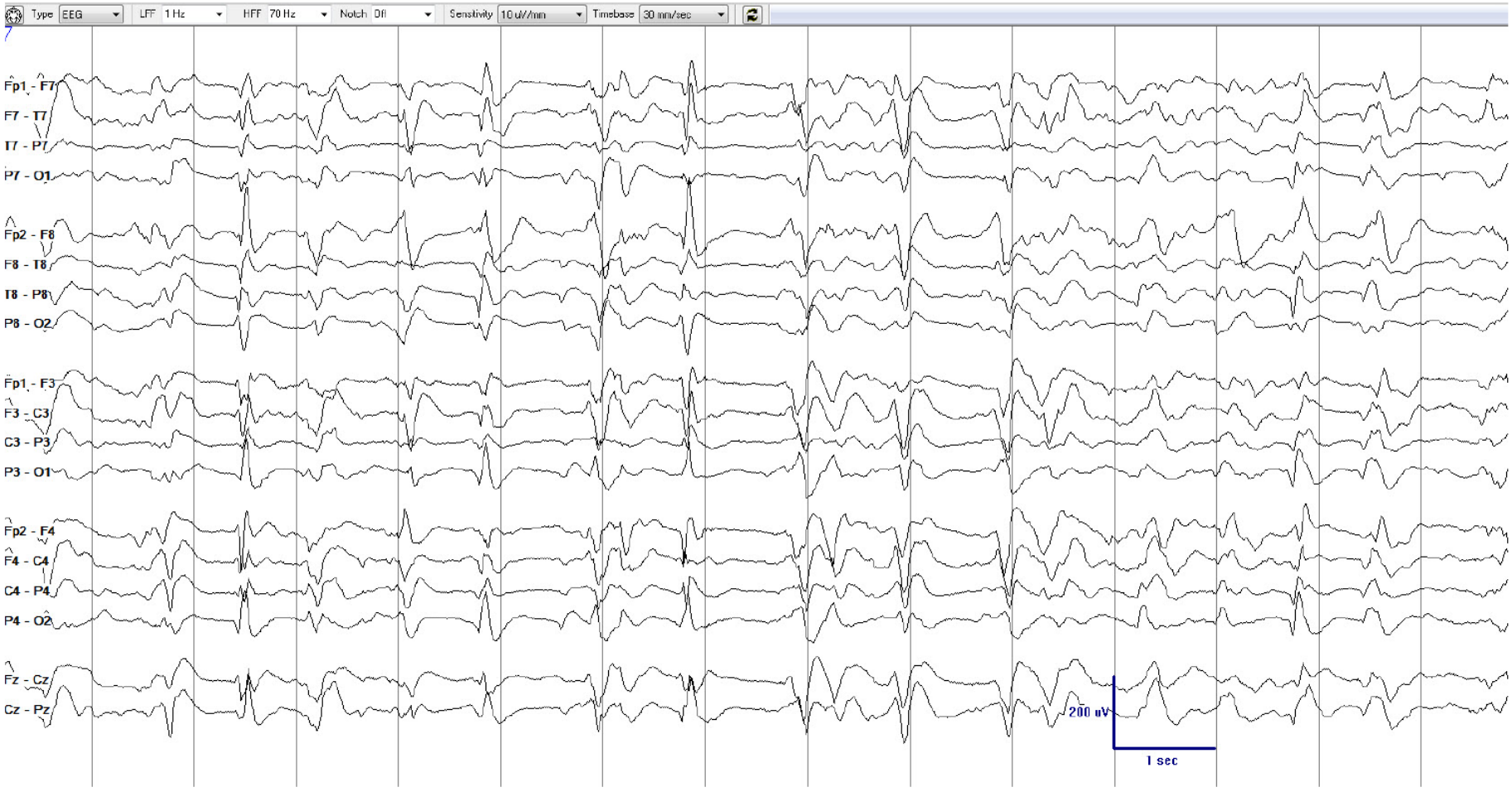
Slides from ACNS Critical Care EEG Terminology Training Module 2021

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.

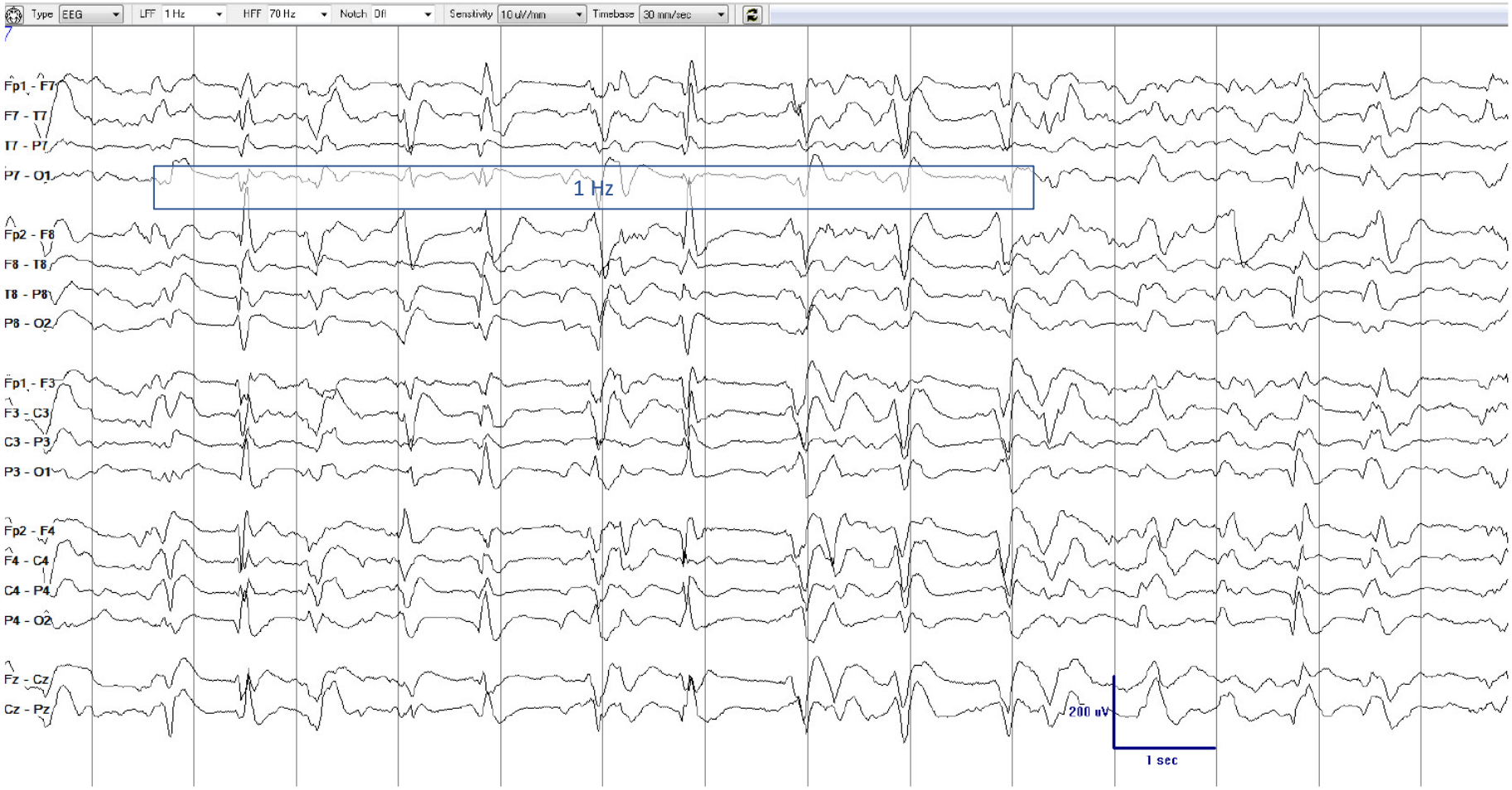
Fluctuation





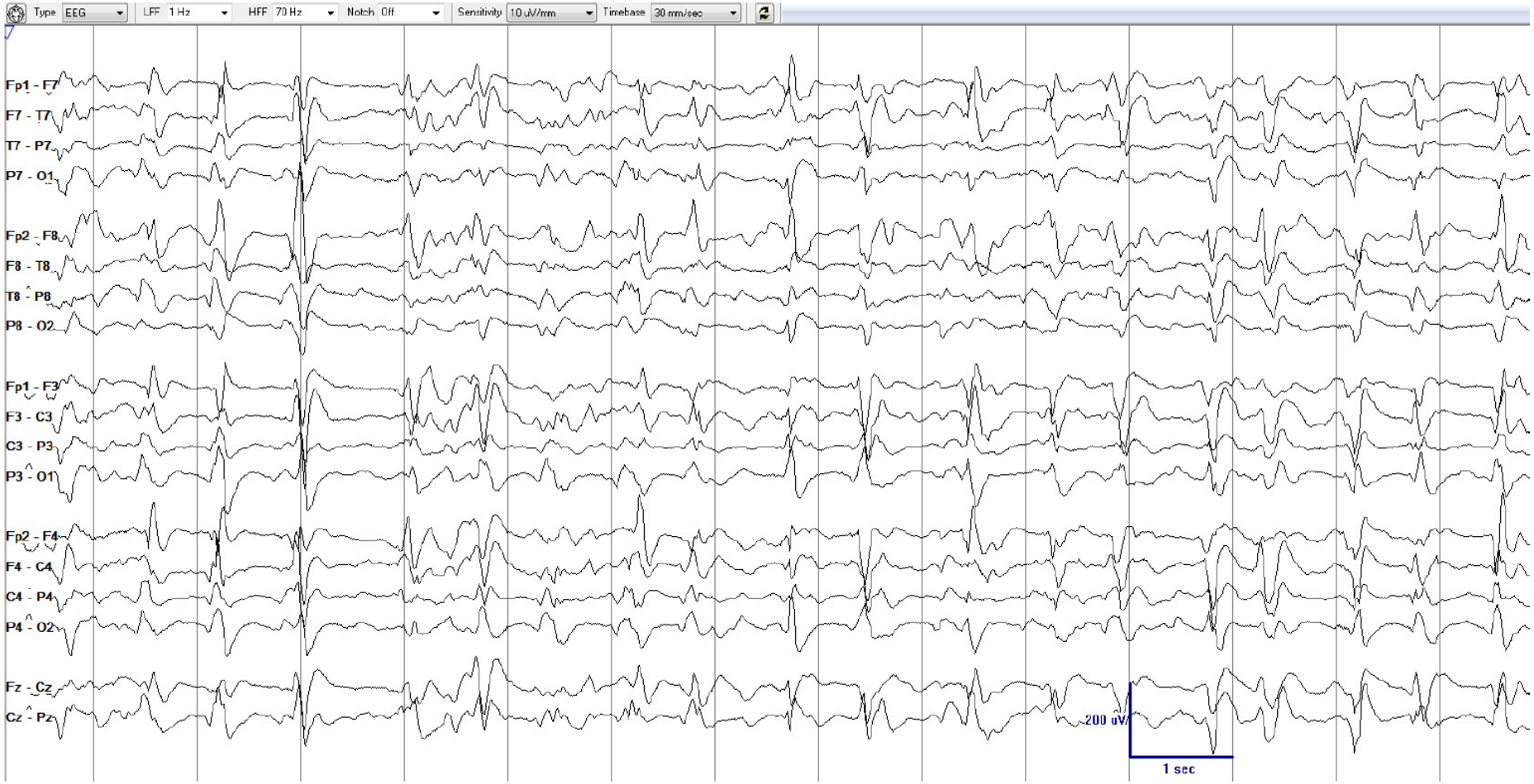
What pattern is this?

Part 1 of 3



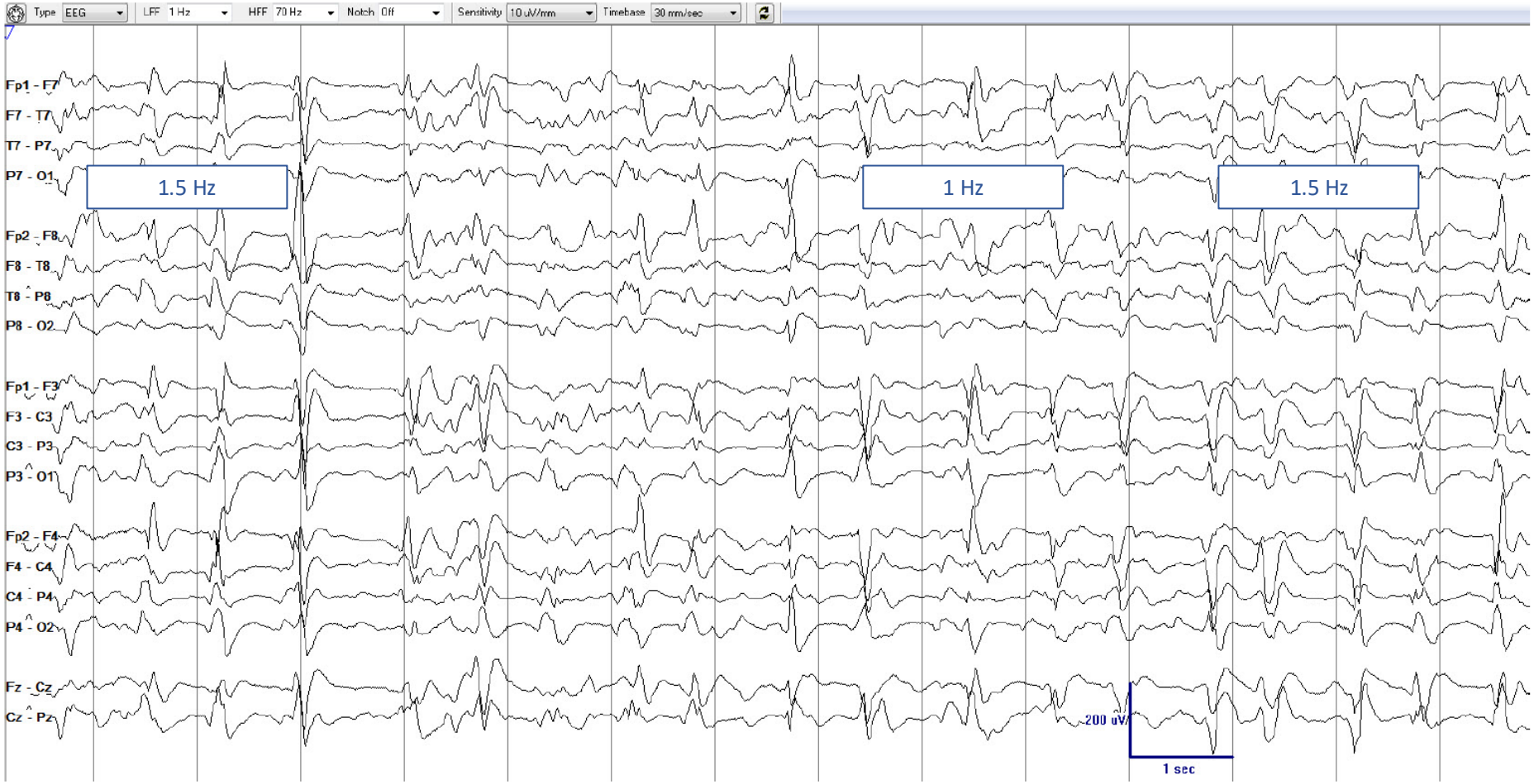
Generalized Periodic Discharges (GPDs), 1.0 Hz, no plus; not on IIC.

Part 1 of 3



How has the EEG changed compared to the prior page?

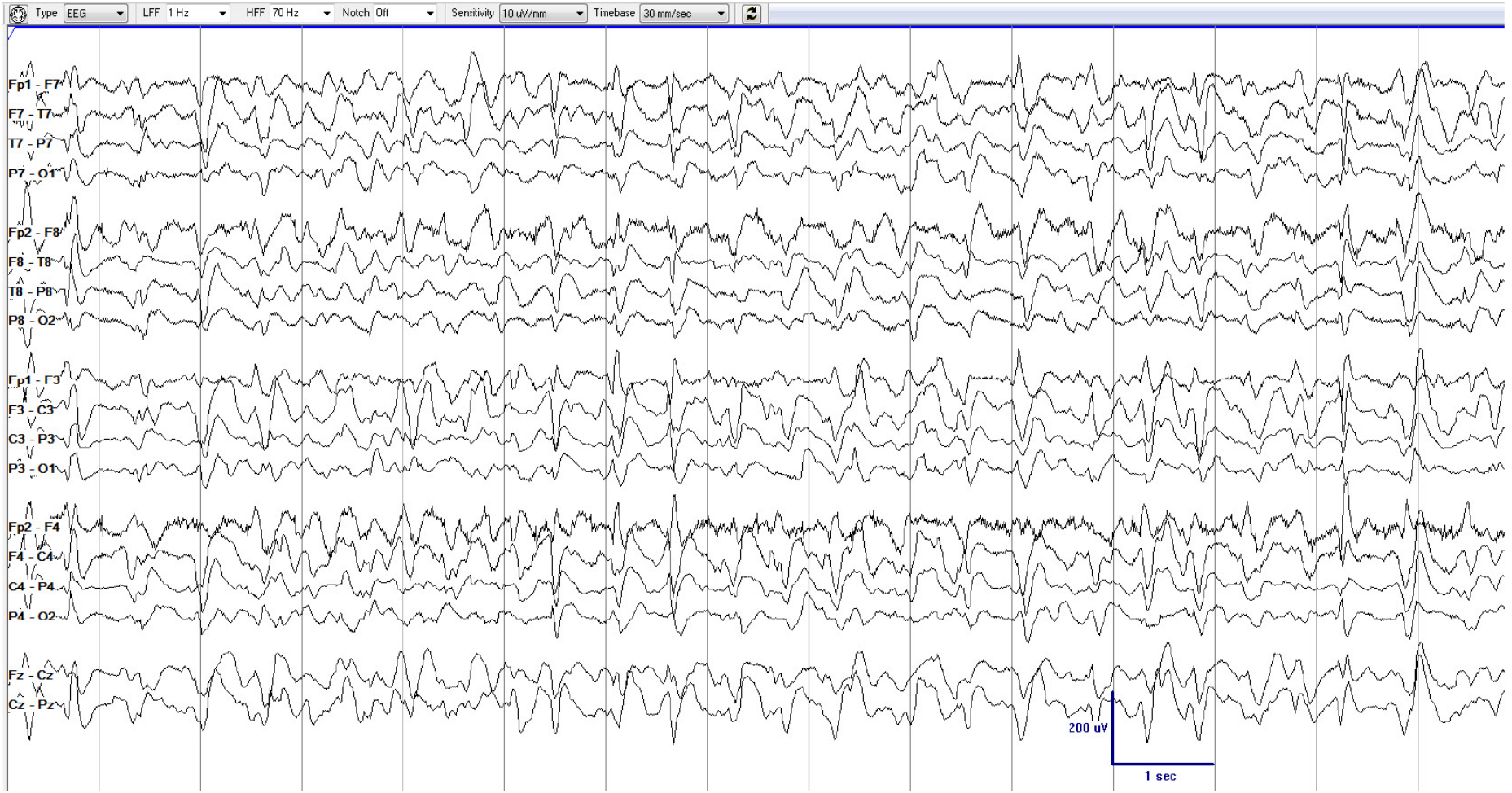
Part 2 of 3



Generalized Periodic discharges with fluctuating frequency: fluctuating GPDs (IIC)

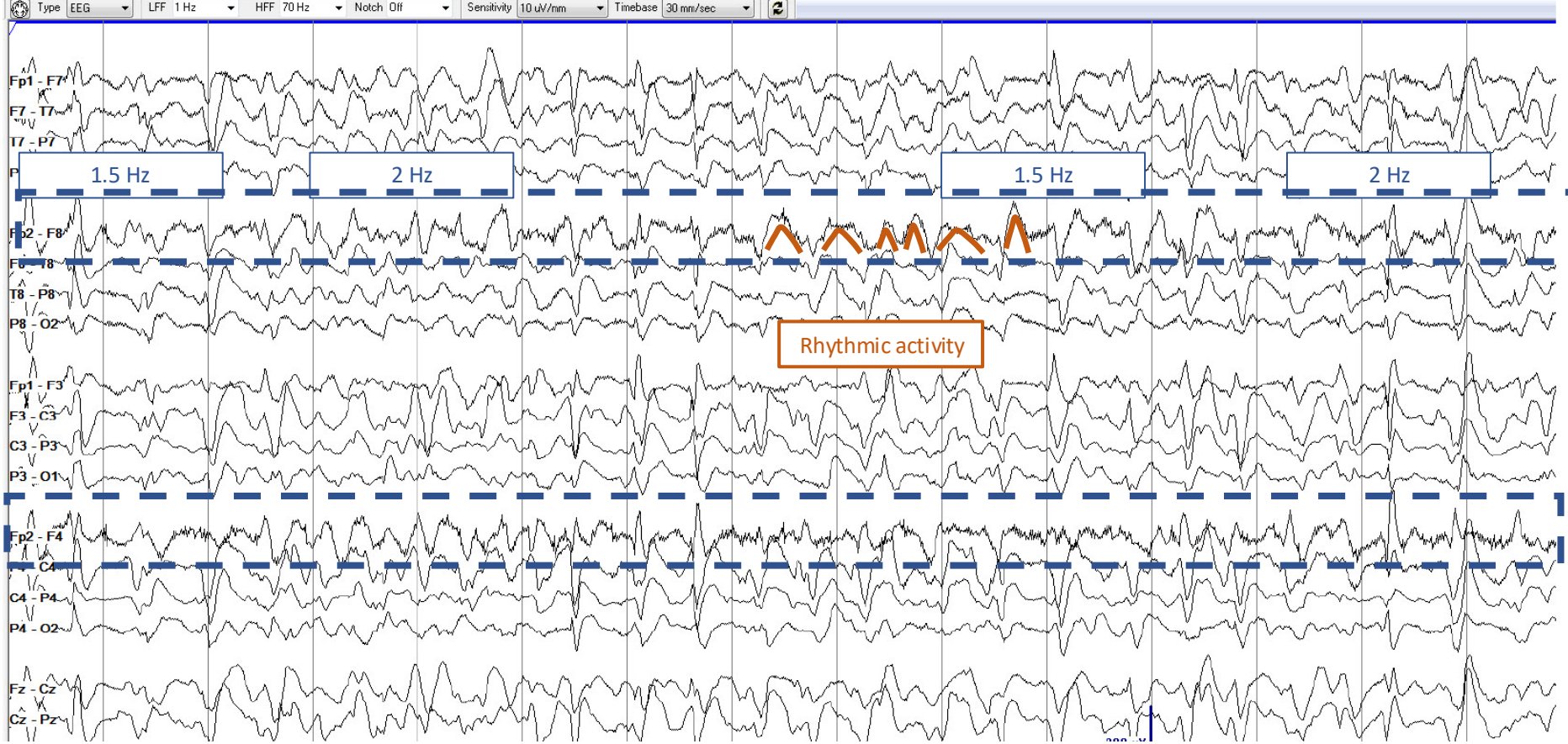
(fluctuating between 1 Hz → 1.5 → 1 → 1.5 Hz: now qualifying as a pattern on the Ictal-Interictal-Continuum [IIC])

Part 2 of 3



How has the EEG changed compared to the prior 2 pages?

Part 3 of 3



GPDs with fluctuating frequency and rhythmic activity; fluctuating GPDs**+R** (IIC)

(1.5 Hz → 2 → 1.5 → 2 Hz, superimposed rhythmic delta activity → +R; Still not definitely ictal, but much closer than the prior page and the page before that; and much more likely to be contributing to symptoms/onging neuronal injury).

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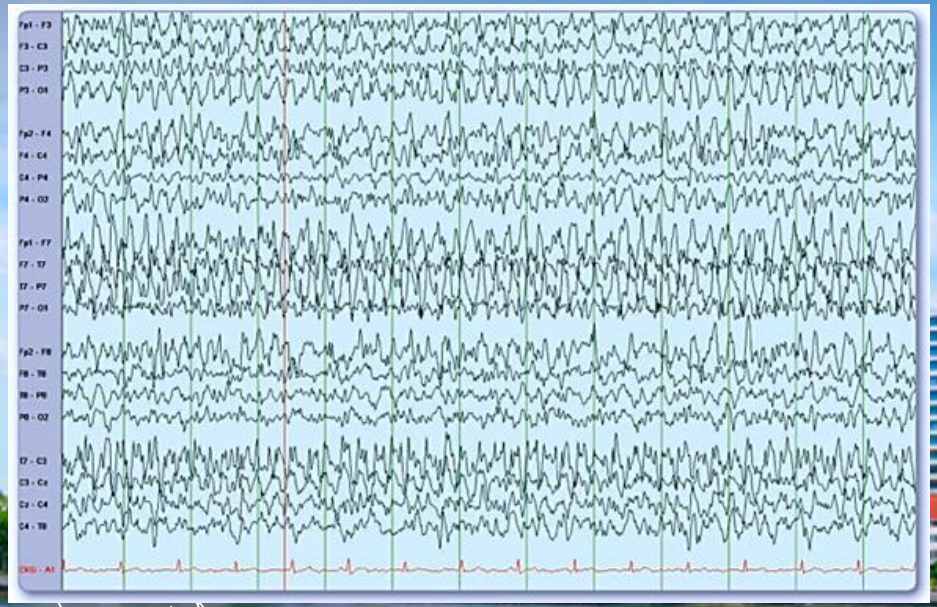
SI-NEURO

NCSE: Real World Diagnostic Challenge

Salzburg Criteria, Borderline, Pitfalls



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