

EEG workshop

Epileptiform abnormalities

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Paroxysmal EEG activities (focal or generalized) are often termed "epileptiform activities"

→ EEG hallmark of epilepsy

- Epileptiform abnormalities are usually divided into
 - * interictal discharges
 - * ictal discharges

Interictal activity
Epileptiform activity occurring between clinical seizures, signaling the presence of a focus

Ictal activity
Epileptiform activity occurring during clinical seizure, very different activity is seen and consisting usually of rhythmic wave forms

Epileptiform discharge ≠ Interictal discharge

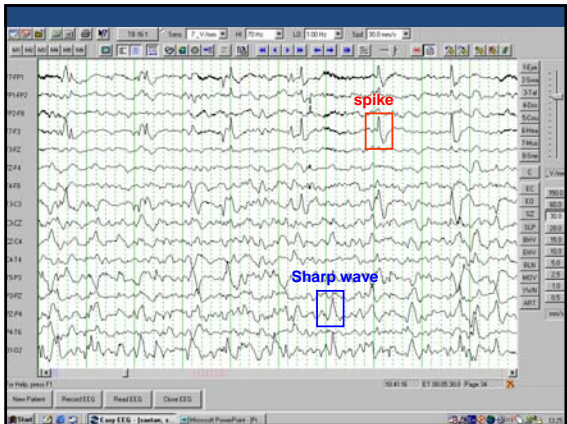
Definitions

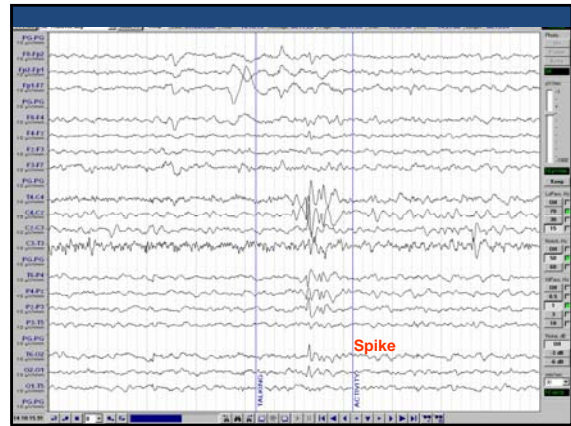
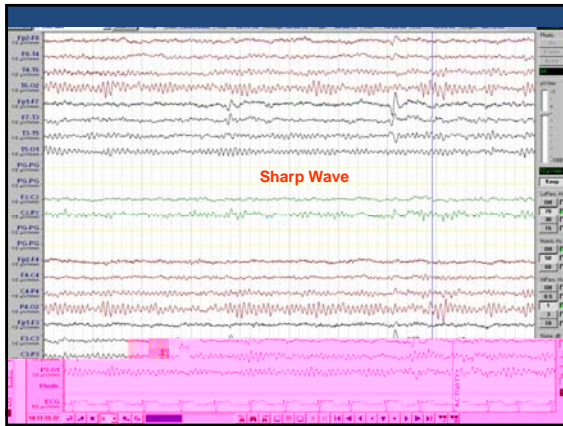
Committee on Terminology of IFSECN (International Federation of Societies for Electroencephalography and Clinical Neurophysiology, 1974)

Epileptiform pattern:
"distinctive wave or complexes, distinguished from background activity, and resembling those recorded in a proportion of human subjects suffering from epileptic disorder..."

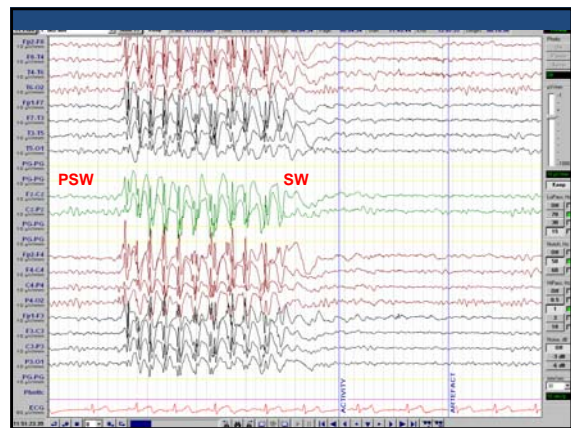
The following definition are in use (IFSECN 1974)

- Sharp wave** - transient , clearly distinguishable from background activity, with pointed peak at conventional paper speeds and a duration of 70-200 millisecond (ms)
- Spike** - same as sharp wave, but with duration of 20 to less than 70 ms





- The following definitions are in use (IFSECN 1974)
- Spike-and-slow-wave complex (SW) – pattern consisting of a spike followed by a slow wave (classically the slow wave being of higher amplitude than the spike)
 - Polyspikes-and-wave complex (PSW) – same as SW, but with 2 or more spikes associated with one or more slow waves



- ### Ictal discharges
- Repetitive EEG discharges with relatively abrupt onset and termination
 - Characteristic pattern of evolution lasting at least several seconds
 - Vary in form, frequency and topography (distribution)

- ### Epileptiform activity
- Localized epileptiform activity
 - focal irritative lesion of the cerebral cortex, acute or chronic
 - Generalized epileptiform activity
 - no detectable abnormality : IGE
 - diffuse cortical and subcortical disorders : structural change or toxic/metabolic disorders
 - symptomatic generalized epileptic syndromes

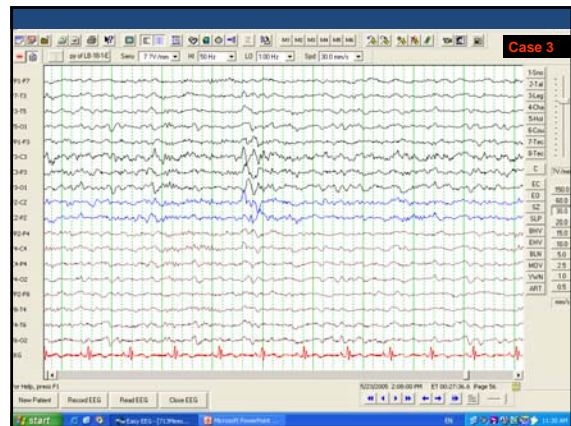
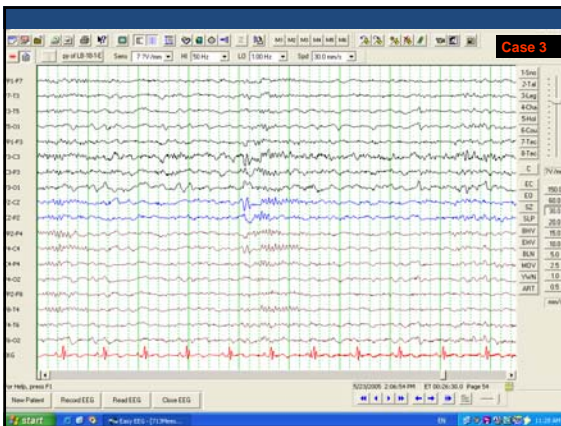
Localized epileptiform activity

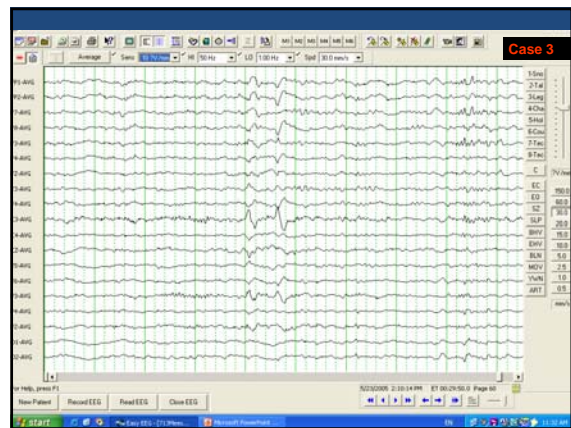
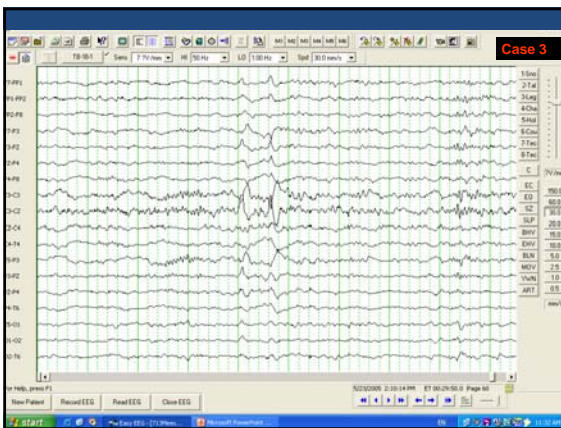
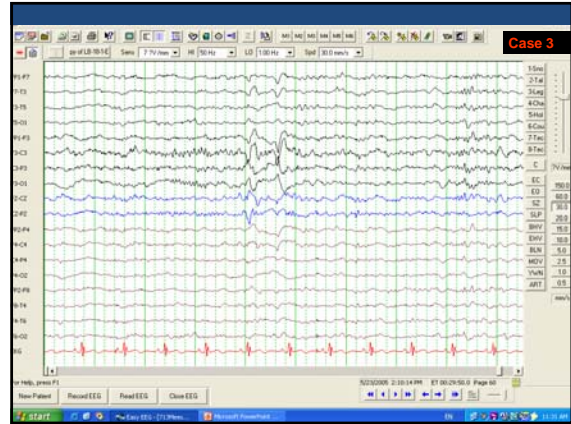
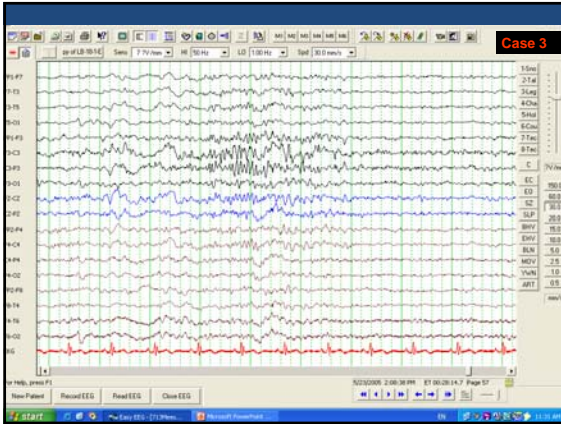
Interictal pattern

Wave shape : single or multiple focal spikes or sharp waves often in combination with slow waves, intermittent, may repeat briefly with little or no variation

Duration : brief duration (< 1 sec.)

Distribution : usually limited to one or a few electrodes





Localized epileptiform activity

Ictal pattern

Wave shape : consists of paroxysmal rhythmic waves with continue to change in shape

Duration : usually persists for several seconds

Distribution : wide distribution, may start at interictal focus and gradually extend to larger areas or rapidly involves both hemispheres in an asymmetric fashion

Localized epileptiform activity

Clinical correlations

In patients with seizure history : Partial seizures

- motor and sensory areas correlate with elementary motor and sensory symptoms
- temporal or fronto-temporal areas correlate with psychic or special sensory symptoms

Localized epileptiform activity

Recurrent focal ictal discharges are usually seen in status epilepticus; if without clinical seizure manifestations : subclinical electrographic status epilepticus

Periodic discharges of focal epileptiform activity or slow waves are seen in patients with epilepsy partialis continua (EPC) or CPSE

Localized epileptiform activity

Clinical correlations

In persons without seizure history

- typical interictal discharges are rarely found (less than 2%), esp. in parietal or occipital areas

In patients with seizure history but without epileptiform activity

- 20-40% of patients
- need prolonged recordings and repeat sampling

Generalized epileptiform activity

appear over most or all part of both hemispheres, usually similar shape, amplitude and timing in corresponding areas

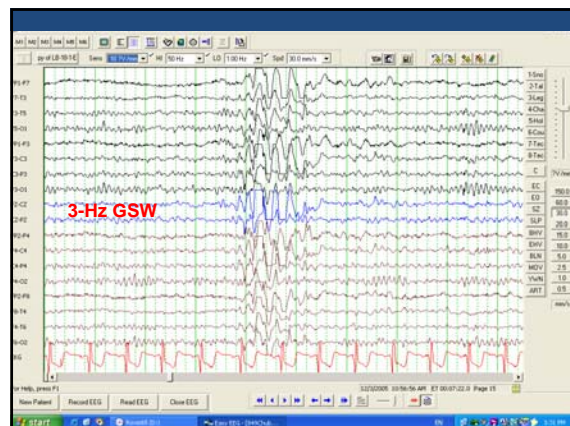
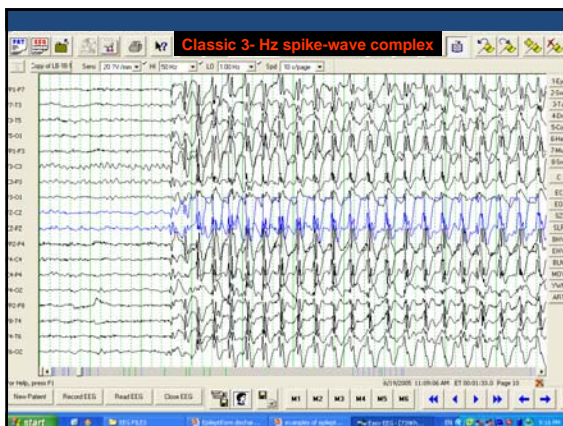
Interictal pattern : brief repetitive discharges, often of GSW at regular intervals

Ictal pattern : longer repetition of interictal discharges or patterns containing different, progressively changing elements

Generalized spike-wave complex

Classic 3 Hz spike wave complex

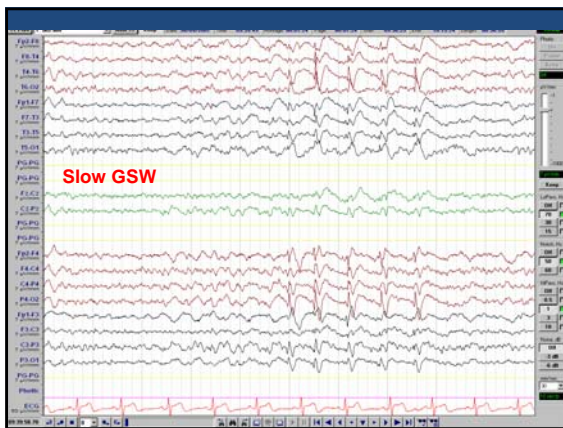
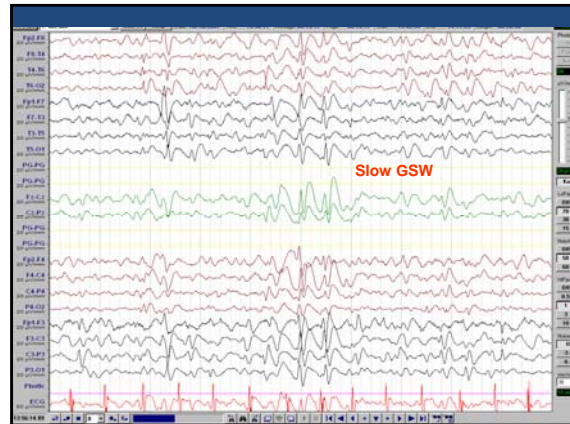
- a spike or spikes of high amplitude followed by a slow wave of similar or higher amplitude
- may be faster (4 Hz) at the onset and then slow down to 2.5 Hz at the end
- maximum over the frontal midline region
- induced by hyperventilation
- typical in absence seizure



Generalized spike-wave complex

Slow spike wave complex (1-2.5 Hz)

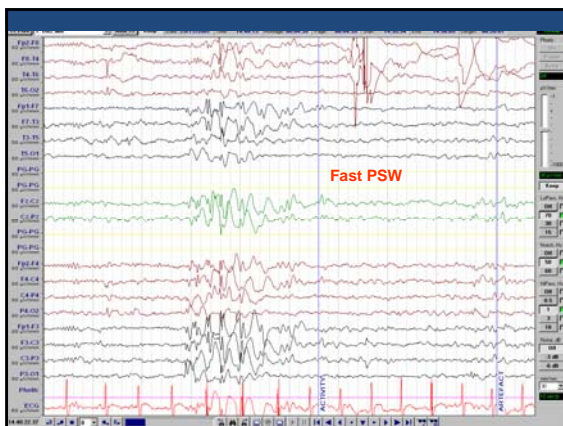
- usually bilateral or generalized synchronous, may be lateralized or local
- maximum over the frontal midline region
- often quite prolonged e.g. the entire sleep portion (light and moderately deep non-REM sleep)
- asso. with a severe, uncontrolled childhood epilepsy e.g. LGS



Generalized spike-wave complex

Fast spike wave complex (4 Hz, 4-5 Hz)

- closely related to the classic 3 Hz spike wave complex
- usually short duration (1-3 sec)
- maximum over the frontal midline region
- associated with myoclonic jerkings or generalized seizure
- frequent positive family history of epilepsy



Generalized epileptiform activity

Clinical correlations

In patients with seizure history

- primary generalized epilepsy : idiopathic, symptomatic
- partial seizure with secondarily generalized seizure

Generalized epileptiform activity

Clinical correlations

In persons without seizure history

family members of patients with IGE, occasionally in metabolic/toxic encephalopathies

In patients with seizure history but without epileptiform activity

- patients with generalized seizure from transient disorders
- epileptiform activity is obscured by artifact

Periodic complexes

- **Rhythmic** : Repetition of a waveform with relatively uniform morphology and duration and no interval between consecutive waveforms
- **Periodic** : Repetition of a waveform with relatively uniform morphology and duration with a definable and quantifiable interval between consecutive waveforms and recurrences of the waveform at nearly regular intervals

Quasi-rhythmic or quasi-periodic = semi- or pseudo-

Periodic complexes

Prefixes

1. Persistence

- Continuous: more than 90% of record
- Abundant: 50% to 90% of record
- Frequent: 10% to 50% of record
- Occasional: 1% to 10% of record
- Rare: less than 1% of record

Periodic complexes

Prefixes

2. Duration

- Very prolonged : more than 1 hour
- Prolonged : 5 minutes to 1 hour
- Intermediate duration : 1 to 5 minutes
- Brief : 10 seconds to 1 minute
- Very brief : less than 10 seconds

Periodic complexes

Prefixes

3. Frequency (rate per second)

e.g. 0.5 per second, 1 per second or 1 or 2 per second

4. Stimulus induced (SI)

repetitively brought about by an alerting stimulus, with or without clinical alerting, though may also be seen with spontaneous arousal

Periodic complexes

Suffixes

Plus (+)

- additional superimposed fast activity or other superimposed pattern or feature that renders the pattern more ictal-appearing than the usual term without the plus

- for rhythmic delta activity (RDA), this includes frequent intermixed sharp waves or spikes

Periodic complexes

1. Periodic lateralizing epileptiform discharges (PLEDs)
2. Bilateral periodic lateralizing epileptiform discharges (BIPLEDs)
3. Generalized periodic epileptiform discharges (GPEDs)
4. Triphasic waves

Periodic lateralizing epileptiform discharges (PLEDs)

Interdischarge interval : typical 0.5 to 4 s, up to 8 s

Topography : lateralized (contralateral spread common)

Rate of focal or tonic-clonic seizures : high (~80%)

Associated myoclonus : rare

Mental status : altered

Outcome : variable

Morphology : variable, associated with EPC

Etiology : acute structural lesion e.g. infarction, ICH, tumor or infection; occasionally no lesion. * Metabolic disturbance, HSE

Periodic lateralizing epileptiform discharges (PLEDs)

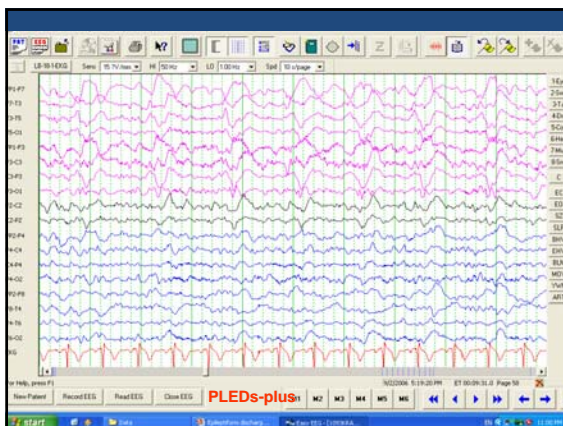
PLEDs-proper

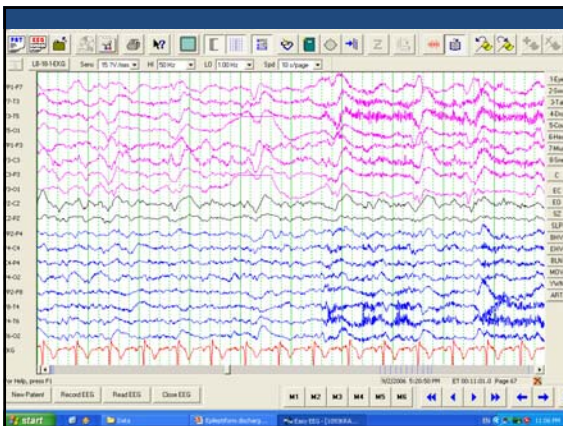
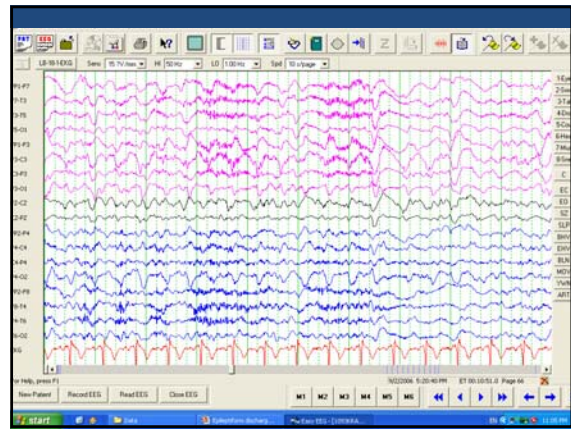
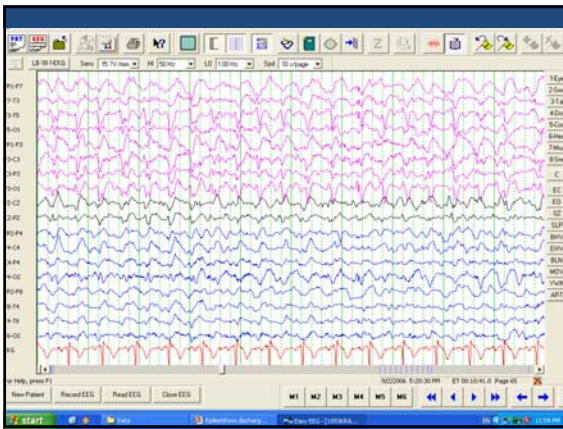
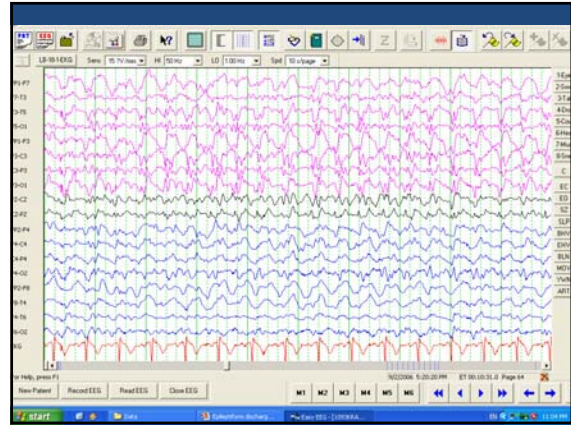
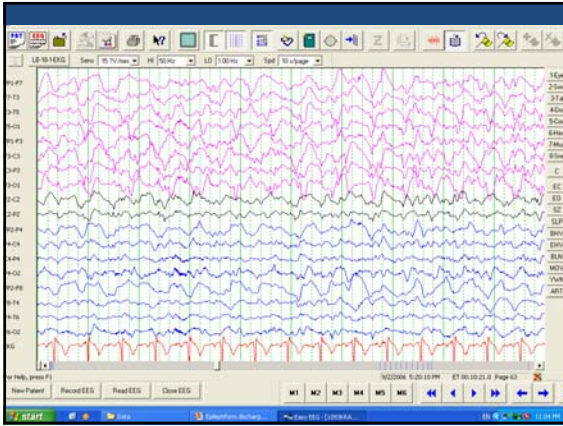
relatively stable periodicity and no associated rhythmic discharges

PLEDs-plus

variable periodicity and associated rhythmic activity with the discharges

Reiher et al., *Electroencephalogr Clin Neurophysiol*, 1991;78:12-7





Bilateral periodic lateralizing epileptiform discharges (BPLEDs)

Interdischarge interval : typical 0.5 to 4 s, up to 8 s

Topography : independently lateralized

Rate of focal or tonic-clonic seizures : typically < in PLEDs but still high

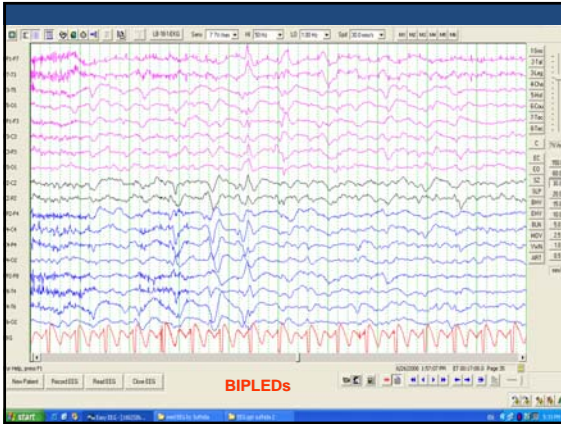
Associated myoclonus : rare

Mental status : altered

Outcome : variable

Morphology : variable

Etiology : anoxia, bilateral acute lesions; occasionally unilateral or no lesion. *HSE



Generalized periodic epileptiform discharges (GPEDs)

- Periodic short-interval diffuse discharges (PSIDDs)*
- Periodic long-interval diffuse discharges (PLIDDs)*
- Burst-suppression pattern

*Brenner and Schaul., J Clin Neurophysiol 1990;7:249-67.

Periodic short-interval diffuse discharges (PSIDDs)

Interdischarge interval : 0.5 to 4 s

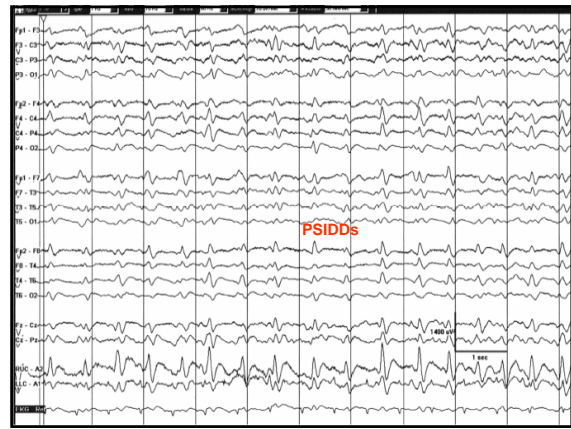
Topography : diffuse

Rate of focal or tonic-clonic seizures : variable, but not rare

Associated myoclonus : common with CJD but often not time-locked

Morphology : sharp waves, spikes, polyspikes, or sharply-contoured delta

Etiology : metabolic encephalopathy, anoxia, NCSE. After SE, lithium, baclofen **CJD**



Periodic long-interval diffuse discharges (PLIDDs)

Interdischarge interval : 4 -30 s

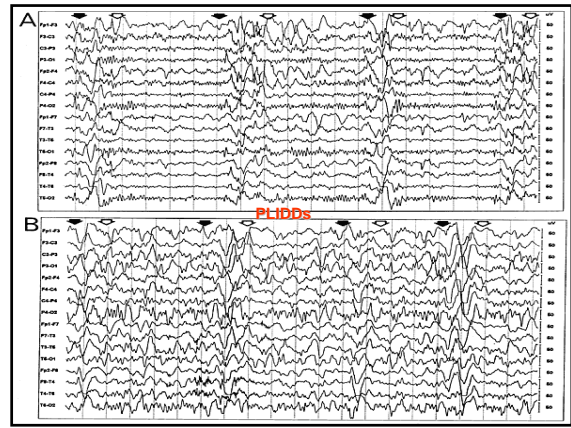
Topography : diffuse

Rate of focal or tonic-clonic seizures : rare

Associated myoclonus : common with SSPE, time-locked

Morphology : variable; often complex, stereotyped, polyphasic bursts, lasting 0.5 - 3 s

Etiology : toxin (PSP, ketamine, barbiturates, anesthetics), anoxia, **SSPE**



Burst-suppression pattern

Wave shape : high-voltage bursts of irregular or regular slow wave with or w/o sharp waves

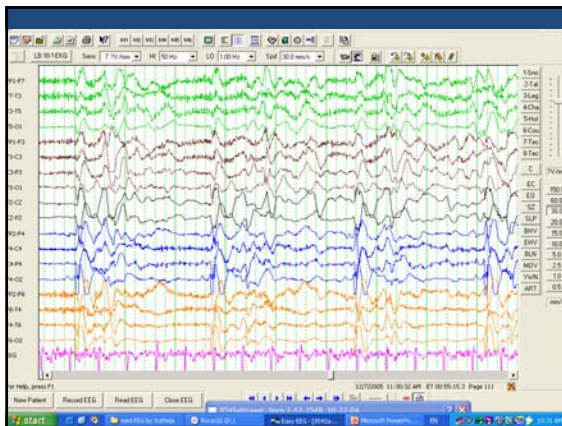
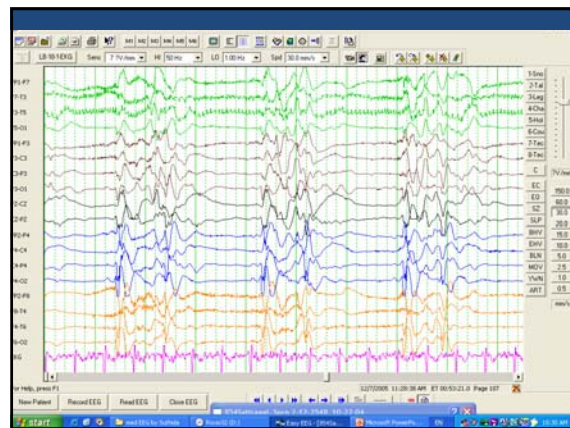
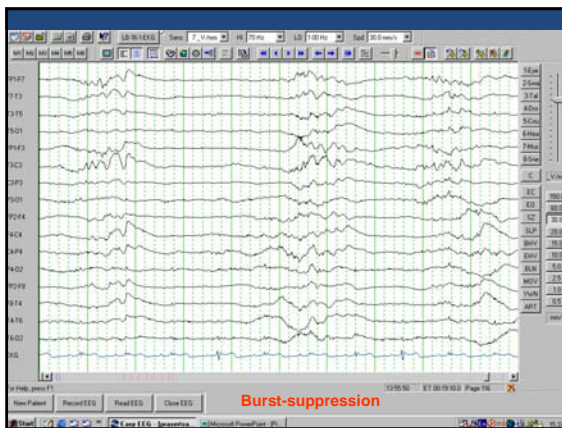
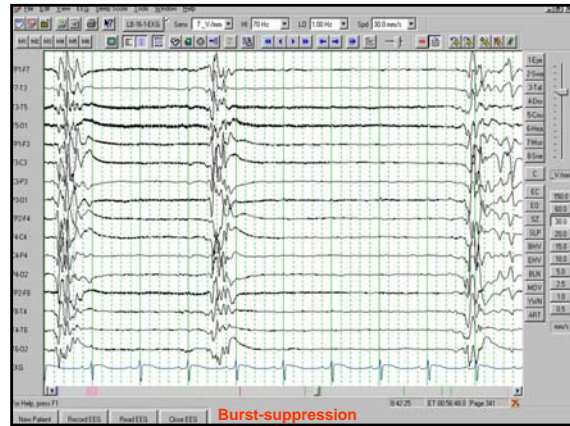
Wave duration: 1-3 s

Interdischarge interval : depressed background or complete flatness lasting 2 s to many minutes

Topography : bilateral

Rate of seizures : rare

Etiology : anesthesia, CNS depressant drugs, hypothermia, anoxia



Triphasic waves

Wave shape : sharp wave or sharply contoured delta waves with a triphasic morphology (negative / positive / negative polarity, with each phase lasting longer than the prior)

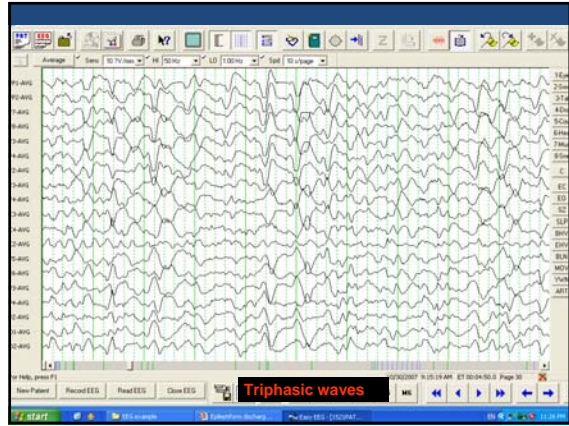
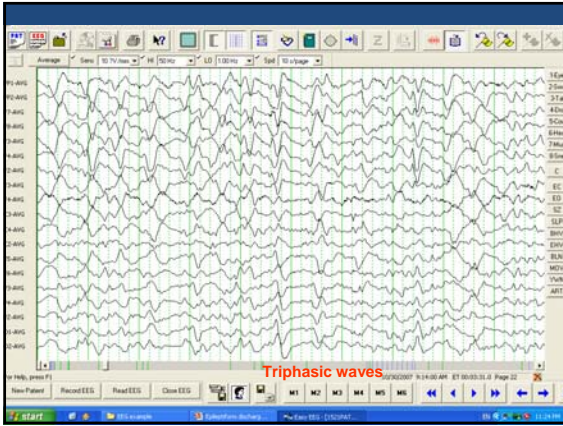
Wave duration: 0.2 - 0.5 s

Interdischarge interval 1-3 s

Topography : generalized, max. at frontal or occipital

Rate of seizures : none

Etiology : hepatic, uremic and other metabolic encephalopathies, anoxia



- Stimulus-induced rhythmic, periodic, or ictal discharges (SIRPIDs)**
- Periodic, rhythmic, or ictal appearing discharges that were consistently induced by alerting stimuli such as auditory stimuli, sternal rub, examination, suctioning, turning, and other patient-care activities
 - Subcategory
 - a. Periodic : GPEDs, PLEDs, Triphasics, Generalized polyspikes, Multiple periodic pattern
 - b. Ictal – appearing : Focal, Generalized, Focal and generalized
 - c. Frontal rhythmic delta activity (FRDA)
 - Relation between SIRPIDs and seizures remains unclear
- Hirsch et al., *Epilepsia* 2004;45:109-23

