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DISCLOSURE OF RELEVANT FINANCIAL RELATIONSHIP(S) WITH INELIGIBLE COMPANIES

Nothing to disclose

REFERENCES TO OFF-LABEL USAGE(S) OF PHARMACEUTICALS OR INSTRUMENTS

Nothing to disclose

All relevant financial relationships have been mitigated.



DEFINITIONS

- Encephalopathy
 - Encephalo- = brain -pathy = dysfunction, disease, impairment, etc.
- In the inpatient setting, most commonly lumped in with "altered mental
- status"
- Several descriptive variables
 - Acute or chronic

 - Static or dynamic
 Focal or generalized
 - Spectrum of severity mild to severe

DEFINITIONS

- · Coma a deep state of unconsciousness (unresponsive and unaware)
- May be caused from any number of etiologies
 - latrogenic (anesthetic)
 - · Hemispheric, brainstem, or diffuse injury
 - Ischemic stroke or hemorrhage
 - Infection Inflammation
 - Trauma
 - Mass or tumor
- · Coma is a severe form of encephalopathy

THE ROLE OF EEG

- Etiology
 - Status epilepticus may be primary or secondary
- Localization More so prior to days of imaging
 - Still helpful if imaging is negative
- Prognosis* more in anoxic injury than other causes of encephalopathy/coma
- Supporting information for or against brain death if unable to perform a complete brain death examination

COMMON PATTERNS

- Slowing
- Rhythmic delta activity
- Periodic discharges · Ictal-interictal continuum

SLOWING

• A general sign of encephalopathy – nonspecific

- Ranges from mild (theta) to severe (delta), and anywhere in between
- May be focal if lesion or focal dysfunction
- Often diffuse in the event of systemic disease

RHYTHMIC DELTA ACTIVITY (RDA)

- Repetitive monomorphic waveforms
- >0.5 Hz and <4 Hz
- Little variation in frequency (<50%) between waveform pairs
- At least 6 waves (cycles) • If 1 Hz, then 6 seconds
 - If 2 Hz, then 3 seconds
- Generalized (GRDA) or lateralized (LRDA)
 GRDA no increased seizure risk compared to non-specific encephalopathy EEGs (~10-15%)
 LRDA 25-40% of patients with seizures

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1-29. Rodriguez Ruiz A, et al. JAMA Neurol. 2017;74(2):181-188. 0020 May Foundation for Media Education and Research | WF10026-1

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PERIODIC DISCHARGES

- Same rules as RDA
- Repetitive
- >0.5 Hz and <4 Hz At least 6 waves (cycles)
- Location, location, location
 - Generalized
 - Lateralized single site
 - Bilateral Independent 2 simultaneous asynchronous sites, different hemispheres
 - Wnilsterel
 Vnilateral Independent 2 simultaneous asynchronous sites, same hemisphere (including midline)
 Multifocal 3+ sites, at least one in each hemisphere

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1 Foreman B, et al. Clin Neurophysiol. 2016;127(2):1073-10 Lin L and Drislane FW. J Clin Neurophysiol. 2018;35(3):189-1 Cold Marc Foundation for Model Economic of Memory 1 (#1000)

PERIODIC DISCHARGES

Generalized Periodic Discharges • Can be with triphasic morphology (previously "triphasic waves")

- Morphology not dependent on cause i.e. triphasic not necessarily toxic/metabolic
- ~25% of patients with GPDs will have seizures
 - Not morphology dependent • May be higher if >2 Hz

Lateralized Periodic Discharges Associated with focal cerebral injury or dysfunction

Can be associated with fast or polyspike components

 More highly associated with discrete seizures, >50% of patients

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1-2 Foreman B, et al. Clin Neurophysiol. 2016;127(2):1073-108 Lin L and Drislane FW. J Clin Neurophysiol. 2018;35(3):189-190

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STIMULUS-INDUCED PERIODIC DISCHARGES (SI-PDS)

Focal, lateralized, or generalized periodic discharges that occur with stimulation

- Part of the ictal-interictal continuum along with other periodic discharges

Formerly called stimulus-induced rhythmic, periodic, or ictal discharges (SIRPIDs)

• NOT considered physiologically normal reactivity

Prognosis?

- Unfavorable in anoxic brain injury
- Not necessarily unfavorable in other reasons for encephalopathy

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1-29 Alvarez V, et al. Clin Neurophysiol 2013;124(1):204-208 Braksick SA, et al. JAMA Neurol 2016;73(5):585-590.

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1-



BRIEF POTENTIALLY ICTAL RHYTHMIC DISCHARGES (BIRDS)

- Not quite interictal...but not quite "seizures" (and definitely not avian) · Increased risk of seizures
- 4+ Hz, at least 0.5 seconds but less than 10 seconds
- At least 6 waves (cycles)
- No clinical correlate if correlate, then it's an electroclinical seizure
- · Classifie as "definite" or "possible" with any single criteria Definite
 - · Evolution (frequency, spread, and/or morphology) OR
 - * Same location as already demonstrated interictal discharges or seizures Possible
 - · Sharply contoured, but not meeting either definite criteria

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NON-CONVULSIVE STATUS EPILEPTICUS (NCSE)

May be easy to tell – repeated well-organized focal seizures or absence status epilepticus

May be difficult to tell with subtle features, persistent encephalopathy

ACNS definition of an electrographic

- ACNS definition of *electrographic* NCSE: EEG seizure at least 10 minutes EEG seizure for at least 20% of any 60-minute epoch
- Acits definition of an electrographic seizure:
 Epileptiform discharges of >2.5 Hz for at least 10 seconds OR
 Any pattern with definite evolution >10 seconds

Hirsh LJ, et al. J Clin Neurophysiol 2021;38:1-Beniczky S, et al. Epilepsia. 2013;54(Suppl 6):28-0022 Marc Transfer Michael Transfer and Transfer 197

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EEG AND COMA

- $\mbox{ \ \ }$ History, examination, and directed diagnostic testing are helpful for assessing coma
- EEG is not diagnostic of coma by itself
- EEG in the absence of clinical information is not reliably prognostic
- Results must be interpreted in the context of other clinical and physiologic information

EEG PROGNOSIS* IN COMA

Good

Reactivity (not SI-PD)

- Spontaneous variability
- Progression to an improved pattern
- Bad • No reactivity • Invariant
- Persistent or progressive suppression, or devolution to a worsened background

*Prognosis is primarily dependent on etiology

EEG AND PROGNOSIS – ANOXIC BRAIN INJURY

 $\mbox{-}$ Anoxic brain injury is the prototypical condition used to assess EEG and prognosis for outcome

Diffuse brain involvement

· Limited other systemic contributors as variables

Anesthetic use (associated with targeted temperature management)
 needs to be taken into consideration

Good (CPC 1-2)	In between	Bad (CPC 3-5)
Continuous any frequency, early	Continuous slowing, late	Discontinuous after 24 hours
	Epileptiform discharges, late	Suppressed background, with or without bursts or periodic discharges
	Heterogeneous burst suppression, early	Low voltage (<10-20 microvolts) after 24 hours
		Epileptiform discharges, early
		Synchronous (stereotypic) burst suppression
		Heterogeneous burst suppression, late





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BRAIN DEATH AND ELECTROCEREBRAL INACTIVITY

- EEG can be used as an *ancillary* test if brain death not able to be confirmed using standard clinical examination and apnea testing
- Electrocerebral inactivity (ECI)
- Is not diagnostic of brain death only a complete brain death exam is able to do that
- Specific requirements

MINIMUM TECHNICAL STANDARDS FOR ECI ON EEG

- Full electrode set-up
- Interelectrode distance 10 cm or more on review ("double distance")
- Resistance between 100-10,000 Ohms
- System integrity tested by qualified individual
- \bullet High sensitivity review (2 $\mu\text{V/mm})$
- HFF: not below 30 Hz
- LFF: not above 1 Hz
- Notch: Ok to use
- Minimum 30 minutes
- No reactivity to any stimuli actively test!
- Repeat if doubt

TROUBLESHOOTING EEG FOR ECI

- Barriers to good recordings
 - ICU artifacts multiple sources
 - ECG artifact utilize ECG monitor as part of EEG
 - $^{\circ}$ Ballistic artifact from pulse utilize ECG monitor as part of EEG
 - Respiratory artifact with ventilator use video monitoring
 - Myogenic artifact can use neuromuscular blocker if needed

If you aren't sure, then it isn't ECI



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TAKE HOME POINTS

- Encephalopathy is a dysfunction of the brain from any number of potential etiologies that ranges in severity and prognosis.
- Slowing, PDs, BIRDs, and status epilepticus may all be seen in encephalopathy.
- LRDA, LPDs, and BIRDs all significantly increase the likelihood of seizures on the EEG recording.
- In anoxic brain injury, prognosis is best if EEG shows a continuous, reactive and variable background early.
- ECI has specific technical requirements and may provide support for or against brain death but does not replace a comprehensive brain death examination.

THANK YOU!

CEREBRAL PERFORMANCE CATEGORY

- 1. Independent, with or without mild neurologic or psychologic impairment
- 2. Independent for ADLs, and can work in a sheltered or accommodating environment
- 3. Conscious and interactive, but dependent on others for care. May or may not have physical deficits (paresis, etc.)
- 4. Coma or vegetative state
- 5. Death/Brain death

<u>Return</u>