Neurosonologic Evaluation of the Ictal-Interictal Continuum

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ASN 42ND ANNUAL MEETING
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PUERTO RICO

DISCLOSURES

No relevant disclosures

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Impact of Seizures in the Critically Ill

- 259 criticaly ill infants and children who prospectively underwent cEEG
- Seizures occured in 36% of patients, including 9% with status epilepticus
- Mean maximum seizure burden per hour was 15.7% in subjects with neurologic decline, versus 1.8% in subjects without neurologic decline
- In multivariable analysis that adjusted for diagnosis and illness severity, for every 1% increase in the max hourly seizure burden, the odds of neurologic decline by 1.13
- Seizures were not associated with mortality

Seizure burden is independently associated with short term outcome in critically ill children

Eric T. Payne,[1] Xiu Yan Zhao,[2] Helena Frndova,[3] Kristin McBain,[3] Rohit Sharma,[1] James S. Hutchison[3] and Cecil D. Hahn[1]

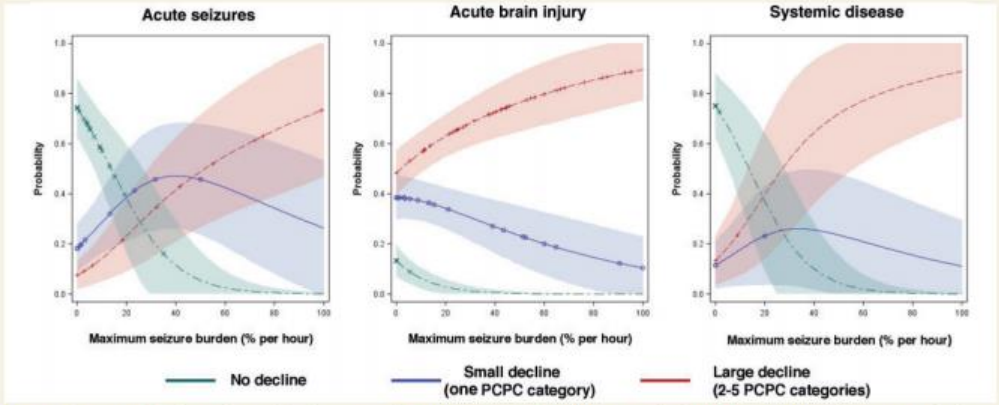


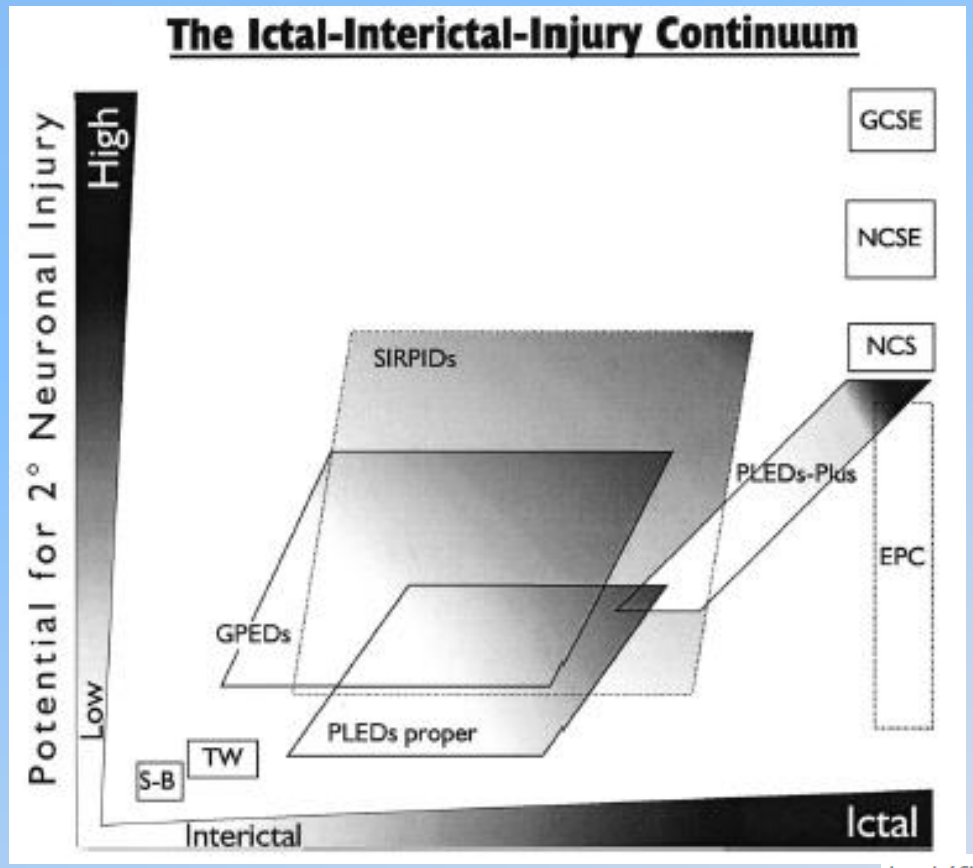
Figure 4 Magnitude of neurological decline rises with increasing seizure burden across all diagnostic categories. The magnitude of neurological decline was categorized as no decline, small decline (a worsening by one PCPC category), and large decline (a worsening by two or more PCPC categories). Multinomial logistic regression with a generalized logit model was fitted and prediction plots were generated to illustrate the probability of neurological decline by seizure burden among the three primary diagnostic categories. The shaded areas represent the 95% confidence intervals. Across all diagnostic categories, as seizure burden increased, the probability of a large decline rose and the probability of no decline fell. The probability of a small decline peaked with moderate seizure burden (30–35% per hour), except among subjects with acute brain injury, where it declined monotonically.

EEG Monitoring in the Critically Ill

- The recognition of status epilepticus and repetitive seizures contributing to neuronal injury has lead to increased utilization of cEEG monitoring
- Decades of cEEG recordings have identified other unique EEG patterns of unclear significance
- These patterns are referred to as the Ictal-Interictal Continuum

Which EEG Patterns Warrant Treatment in the Critically Ill? Reviewing the Evidence for Treatment of Periodic Epileptiform Discharges and Related Patterns

Derek J. Chong and Lawrence J. Hirsch



Journal of Clinical Neurophysiology • Volume 22, Number 2, April 2005

Defining the Ictal-Interictal Continuum

- A dynamic pathophysiologic state of unstable neurological processes that while not always ictal, suggests an increased risk toward evolution to the ictal state.

Generalized periodic epileptiform discharges in critically ill children: Clinical features, and outcome

Cigdem I. Akman[a,b,c,*], Karine J. Abou Khaled[a], Eric Segal[a], Vesna Micic[b], James J. Riviello[b,c]

Epilepsy Research (2013) 106, 378–385

- Retrospective review of 21 critically-ill children who manifested with GPDs on cEEG monitoring
- Most common etiology: encephalitis
- 15/21 manifested with non-convulsive status epilepticus
- 13/21 with clinical seizures after GPDs were detected
- GPDs occurred in 43% of children who had a dose reduction in continuous IV infusion of AED
  - Suggesting an active epileptic state
- Outcomes
  - 5/21 died
  - 7/21 with favorable outcomes
  - Remainder with moderate to severe disability at discharge

De novo generalized periodic discharges (GPDs) related to anesthetic withdrawal (GRAWs) resolve spontaneously

Amar B. Bhatt[1], Alexandra Popescu[2], Elizabeth Waterhouse[3], and Bassel W. Abou-Khalil[1]

J Clin Neurophysiol. 2014 June ; 31(3): 194–198. doi:10.1097/WNP.0000000000000051.

- 5 patients who developed GRAWs during pentobarbital or propofol withdrawal after burst suppression for treatment of refractory status epilepticus
  - 1-4 Hz GPDs not previously seen on patients' EEG
  - In all cases, pattern resolved spontaneously over 12-120 hours
    - 3/5 cases: pattern thought to be ictal activity, and drug-induced coma was reinitiated
      - Pattern recurred during repeated anesthetic withdrawal, recognized as non-ictal, then resolved without further treatment
- 4/5 cases: patients exhibited improvement to near baseline mentation

Challenges within the Ictal-Interictal Continuum

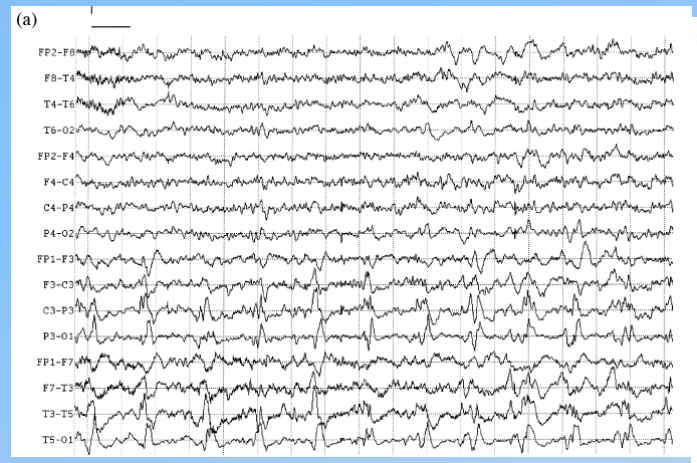
- No clinical gold standard exists for qualifying an ictal pattern
- Most studies of patterns of the ictal-interictal continuum focus on etiology, prognosis and association with seizures
- How do we qualify patterns on the ictal-interictal continuum as either epiphenomenon of neuronal injury or director propagators of injury?

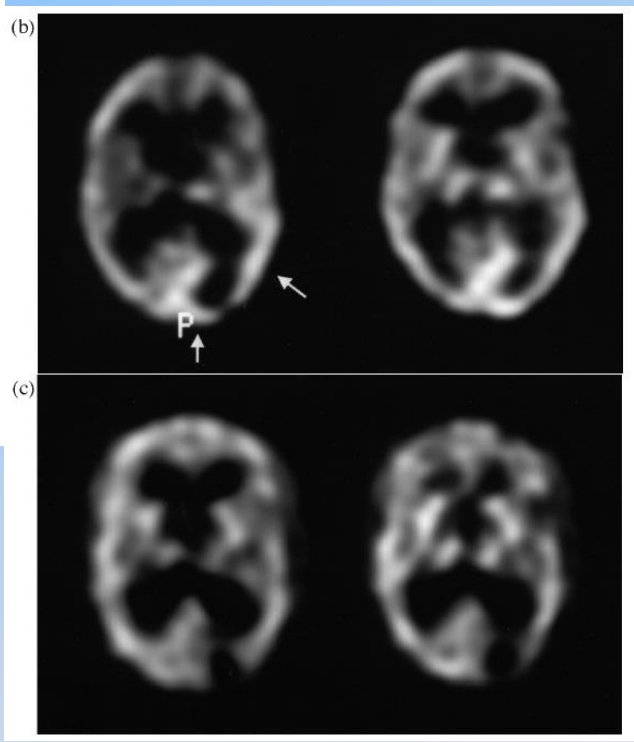
SPECT in periodic lateralized epileptiform discharges (PLEDs): a form of partial status epilepticus?

F. ASSAL[†], J. P. PAPAZYAN[‡], D. O. SLOSMAN[‡], P. JALLON[†] & G. W. GOERRES[§]

Seizure 2001; **10**: 260–264

- SPECT showed high rCBF in 18/18 patients LPDs
  - 17/18 with matched rCBF increase to location of LPDs
- 3 patients with resolution of LPDs undergoing SPECT
  - Resolution of previously seen high rCBF





J Clin Neurophysiol. 2016 Oct 5. [Epub ahead of print]

Perfusion MRI can impact treatment decision in ictal-interictal continuum.

Venkatraman A[1], Khawaja A, Bag AK, Mirza M, Szaflarski JP, Pati S.

Author information

Abstract

Lateralized Periodic Discharges (LPDs) are commonly seen on EEG in critically-ill patients. They are often associated with seizures, but some patients may have them without seizures. Therefore, they are considered to lie in the ictal-interictal continuum. When ictal, they require multiple antiepileptic drugs to treat effectively, which can expose the patient to iatrogenic complications. Therefore, optimal management is controversial. We present here two cases where perfusion-weighted Magnetic Resonance Imaging (pMRI) was useful in distinguishing ictal from interictal LPDs. Findings of pMRI In the first patient, hyperperfusion in the area showing LPDs was considered an indication that the LPDs were ictal, and aggressive treatment led to clinical improvement. The second patient had no asymmetry on pMRI and therefore we did not escalate antiepileptic therapy, and the LPDs resolved spontaneously over the next few days. pMRI offers several advantages over other techniques such as Single Photon Emission Computerized Tomography (SPECT) that have been used for this purpose before. It does not expose the patient to radiation, and newer techniques like arterial spin labeling can even obviate the need for intravenous contrast. Larger scale studies using pMRI will be of great value to clinical practice.

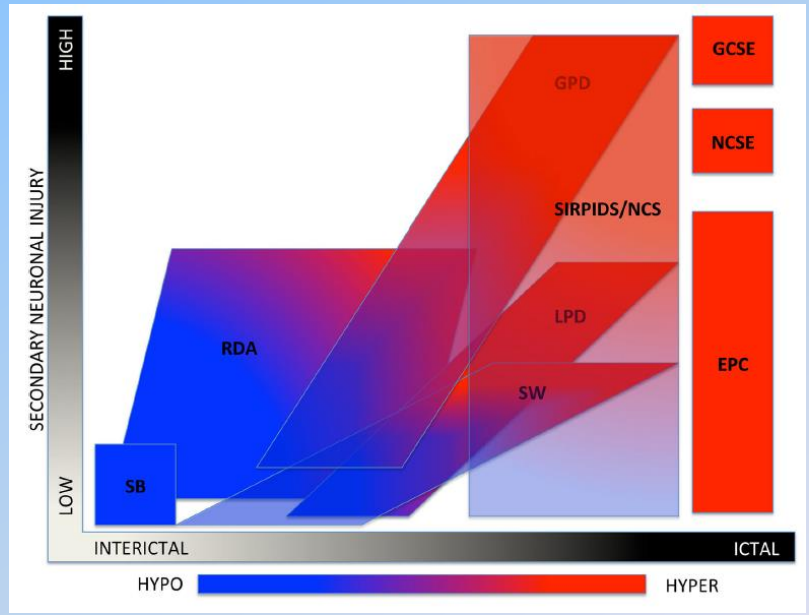
- Two patients with LPDs who underwent pMRI
  - Patient 1: hyperperfusion seen (considered ictal)
    - Aggressive AED treatment
    - Clinical improvement
  - Patient 2: no perfusion asymmetry on pMRI
    - No escalation of AED therapy
    - LPDs resolved spontaneousy over few days

Metabolic Correlates of the Ictal-Interictal Continuum: FDG-PET During Continuous EEG

Aaron F. Struck[1] · M. Brandon Westover[1] · Lance T. Hall[2] · Gina M. Deck[1] · Andrew J. Cole[1] · Eric S. Rosenthal[1]

Neurocrit Care (2016) 24:324–331

- Prospective single-center study of patients undergoing FDG-PET during contemporaneous ictal-interictal patterns.
  - 18 patients with structural lesions (44%), inflammatory/infectious disease (39%) or epilepsy (11%)
- Hyerpetabolism was common (61%) and predicted status epilepticus (sensitivity 79%; specificity 100%)



JAMA Neurology | Original Investigation

Electroencephalographic Periodic Discharges and Frequency-Dependent Brain Tissue Hypoxia in Acute Brain Injury

Jens Witsch, MD; Hans-Peter Frey, PhD; J. Michael Schmidt, PhD; Angela Velazquez, MD; Cristina M. Falo, PhD; Michael Reznik, MD; David Roh, MD; Sachin Agarwal, MD; Soojin Park, MD; E. Sander Connolly, MD; Jan Claassen, MD, PhD

JAMA Neurology Published online January 9, 2017

- Prospective single-center study (Columbia) of adult patients with high-grade aSAH who underwent cEEG monitoring, dEEG monitoring and intracranialmultimodality monitoring
  - 90 subjects
  - 32/90 (36%) had PDs on sEEG and dEEG recordings (23%)
  - 21/90 (23%) had PDs on dEEG recordings
- Change point analysis confirmed a temporal association of high-frequency PD onset (≥2.0 Hz) and PbtO2 reduction.
- Increased regional CBF and global CPP were seen for all higher PD frequencies
- Conclusion: the physiologic signature of high-frequency PDs resemble that described for seizures

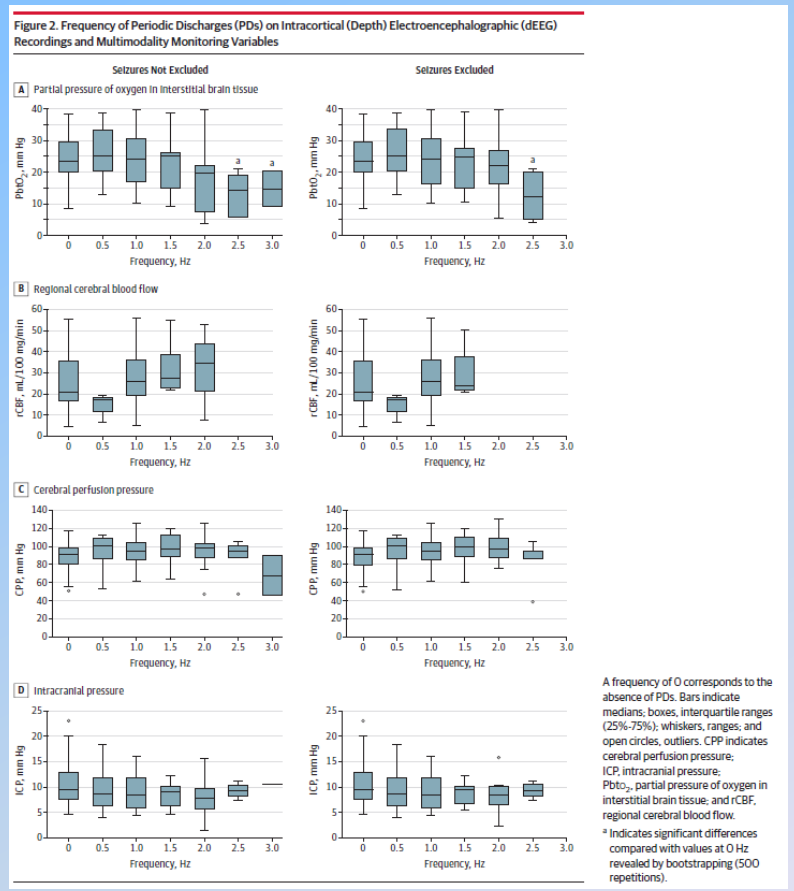


Figure 2. Frequency of Periodic Discharges (PDs) on Intracortical (Depth) Electroencephalographic (dEEG) Recordings and Multimodality Monitoring Variables

A frequency of 0 corresponds to the absence of PDs. Bars indicate medians; boxes, interquartile ranges (25%-75%); whiskers, ranges; and open circles, outliers. CPP indicates cerebral perfusion pressure; ICP, intracranial pressure; $Pbto_2$, partial pressure of oxygen in interstitial brain tissue; and rCBF, regional cerebral blood flow.

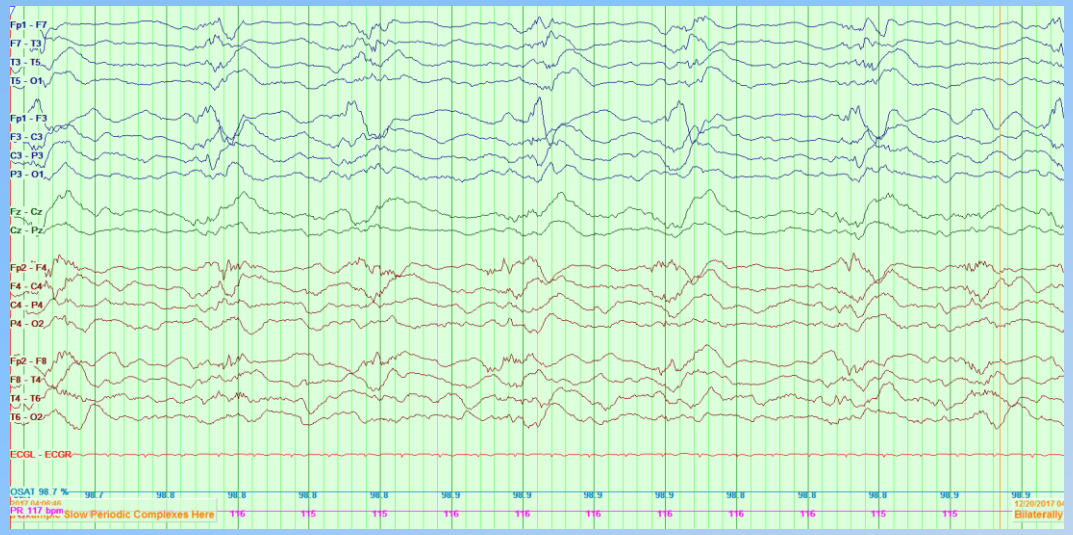
[a] Indicates significant differences compared with values at 0 Hz revealed by bootstrapping (500 repetitions).

What about TCD in evaluating ictal-interictal continuum patterns

- Anatomical neuroimaging studies are often challenging due to a lack of high temporal resolution and need for patient transport.
- Multimodal monitoring techniques often use invasive methods that may not always be clinically appropriate.
- TCD is a non-invasive bedside technique that can provide measures of cerebral blood flow in real time.

Case Example 1

9 year old girl with 3 days of fever and URI symptoms who presents after she stopped talking….



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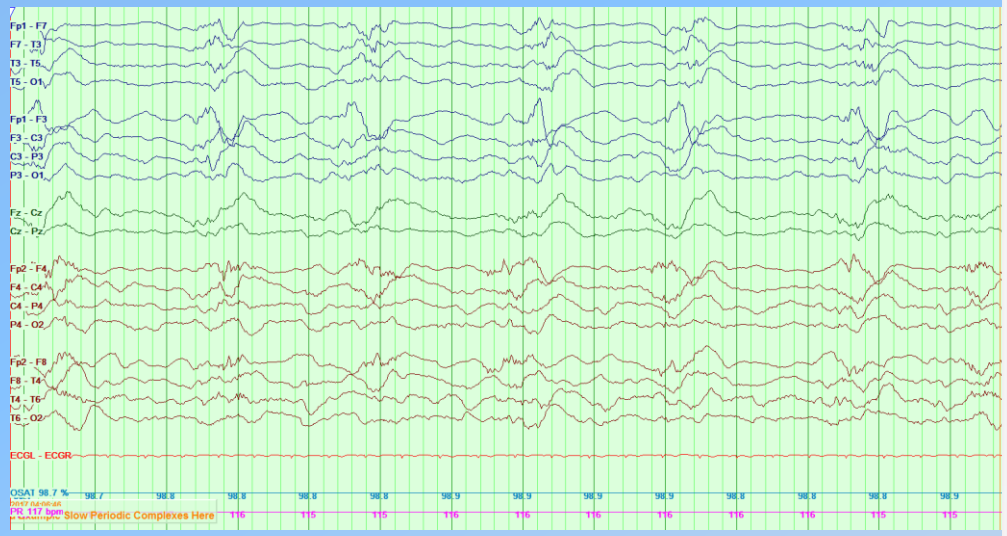

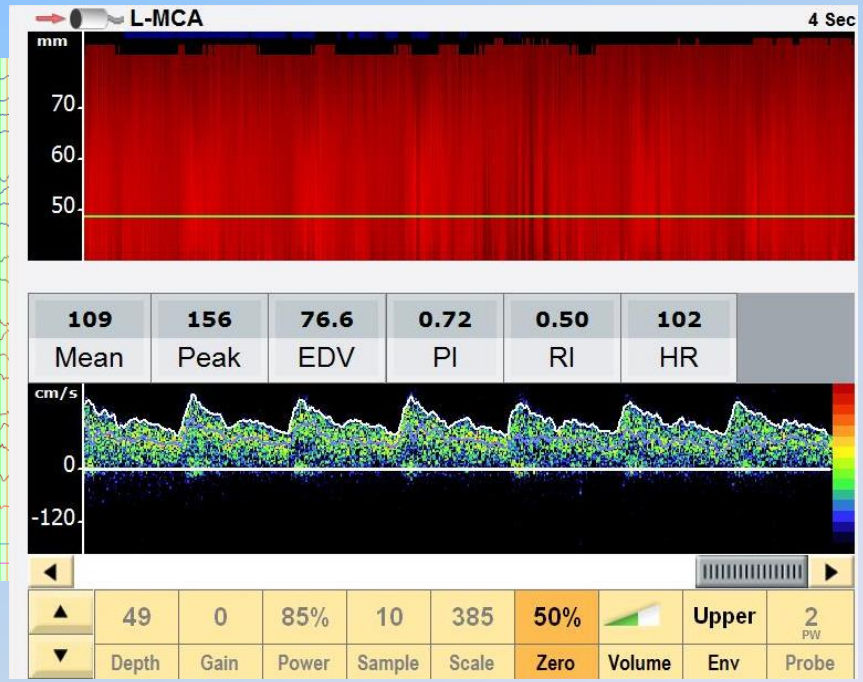

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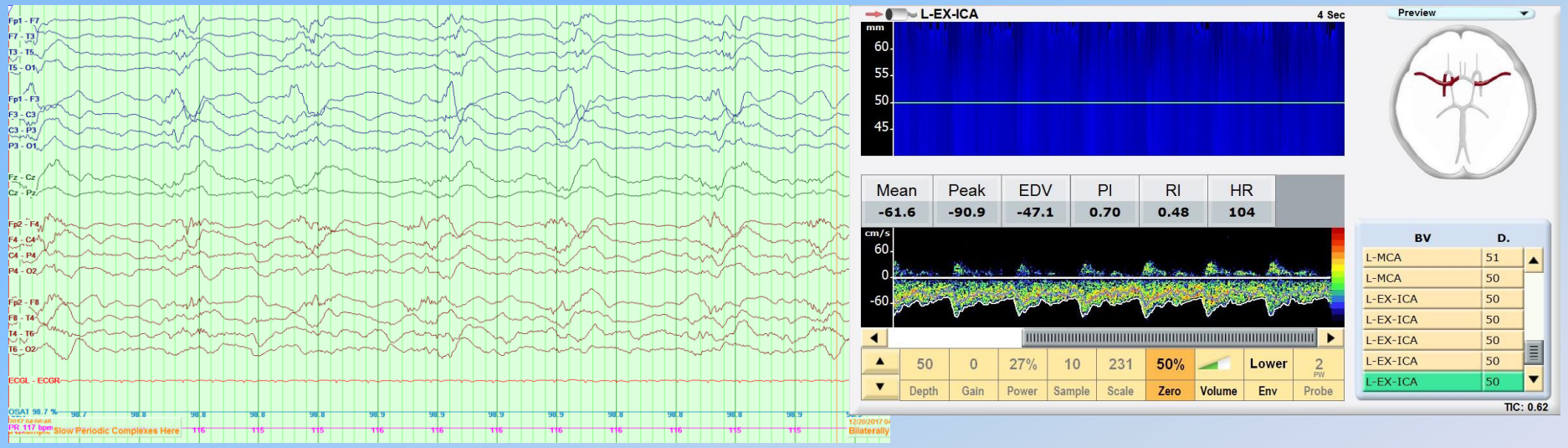

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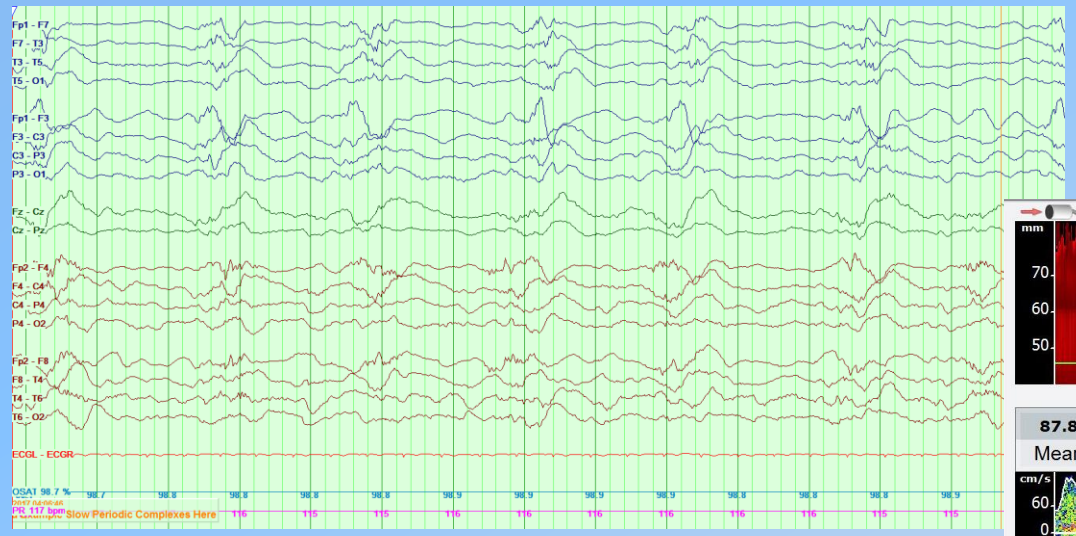

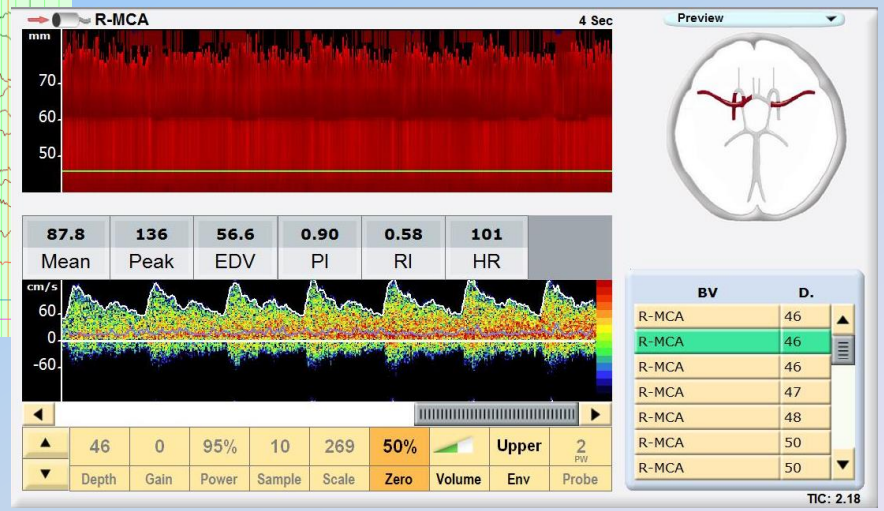

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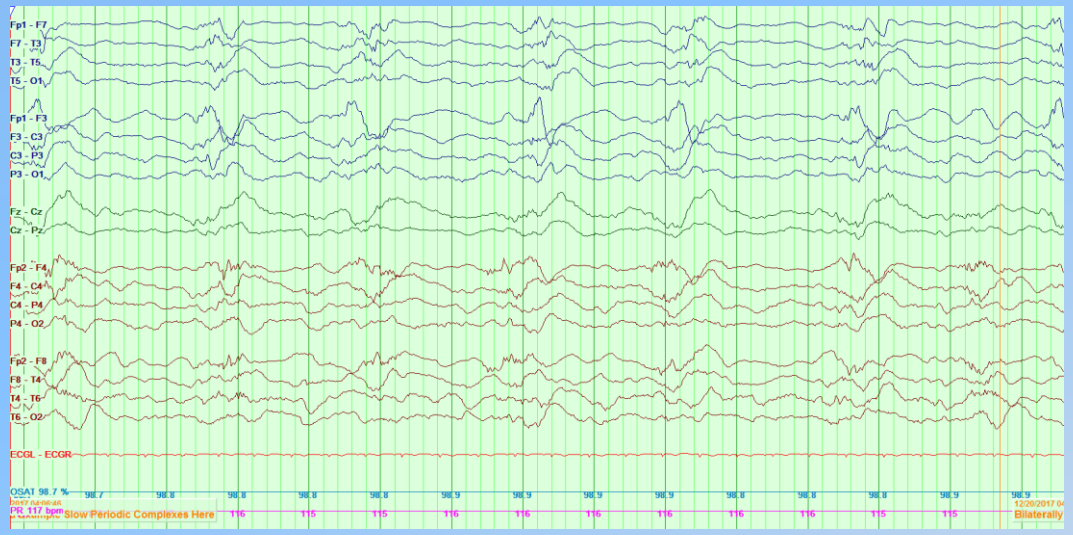
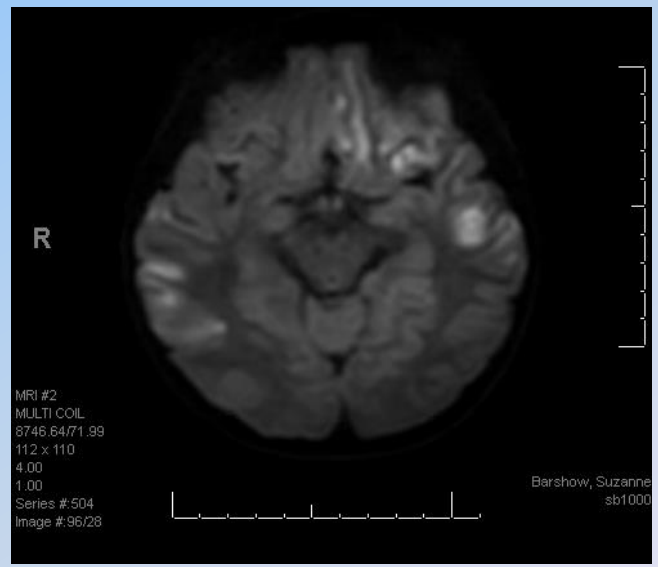
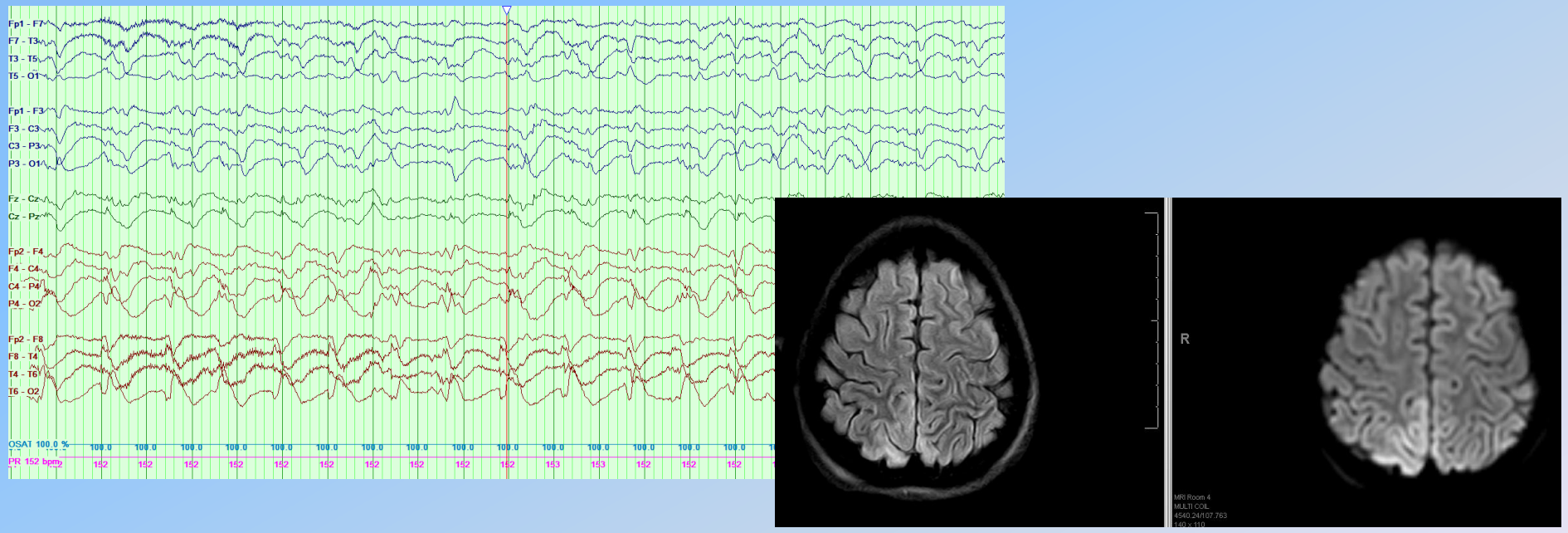




Case Example 2

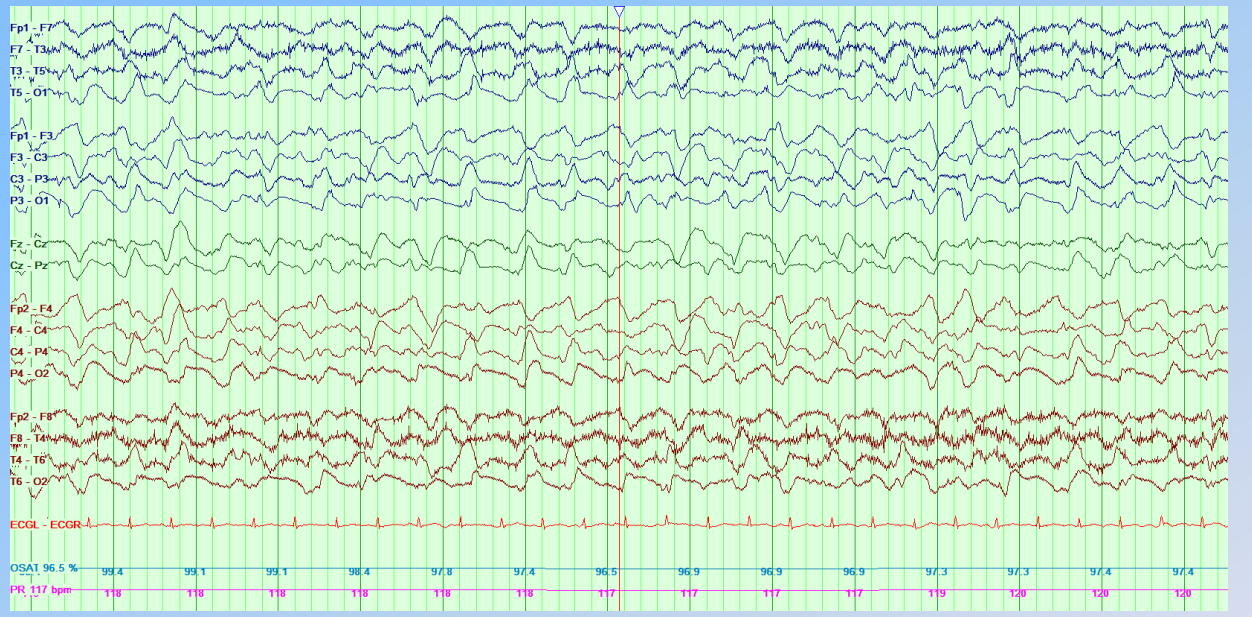
7 year old girl with sickle cell disease presents with altered mental status and hypertension after a blood transfusion



Case Example 2

7 year old girl with sickle cell disease presents with altered mental status and hypertension after a blood transfusion

- Patient receives pentobarbital therapy, achieves seizure remission and burst suppression
- After pentobarbital wean, new pattern emerges…..



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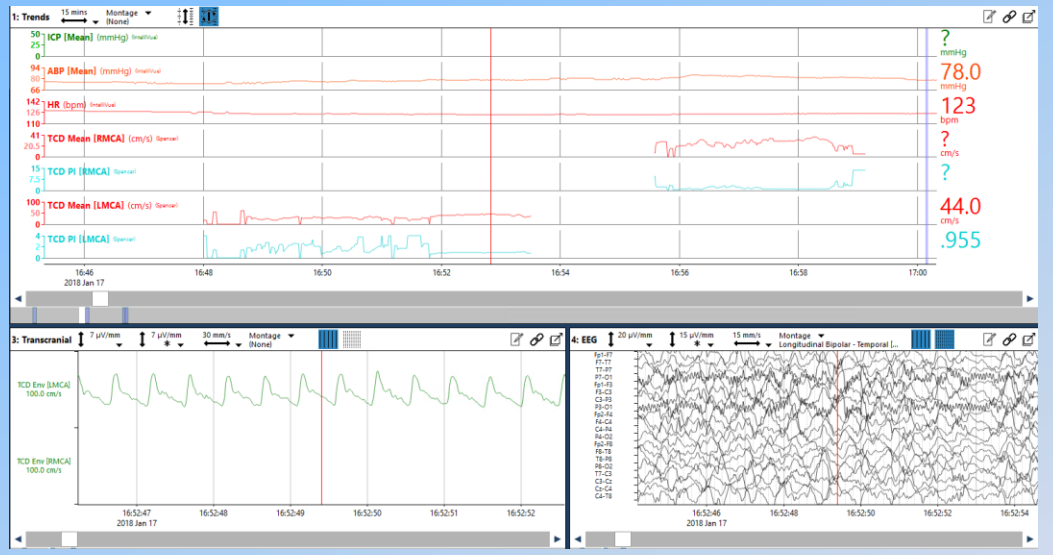
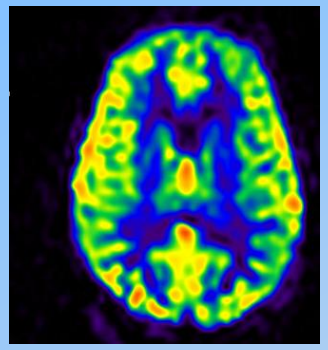
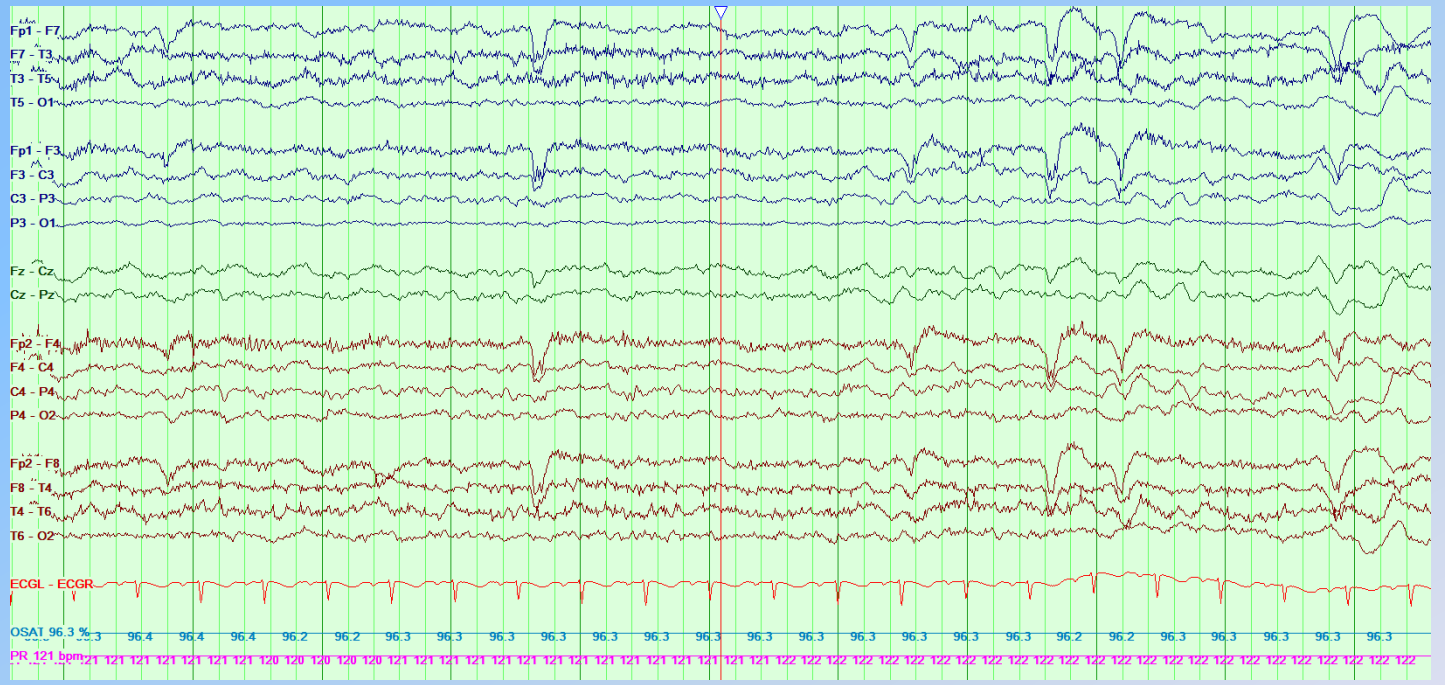




Case Example 2

7 year old girl with sickle cell disease presents with altered mental status and hypertension after a blood transfusion

- 40 hours after sustaining off pentobarbital wean



Conclusion

- TCD is a non-invasive technique that can be performed at the patient's bedside to study cerebral blood flow hemodynamics, and can be repeated at different time points.
- These cases suggest that using TCD to evaluate patients within ictal-interictal continuum patterns may be useful to understanding the nature of their physiologic significance.