Understanding The Basics of Conventional Neonatal EEG

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Why Learn About Neonatal EEG?

The value of neonatal EEG:

- Is very sensitive, but non-specific
- Measures the impact of a disease on the CNS
- Is a premier prognostic tool
- Encephalopathy can arise from a “global” or “focal” disorder and the severity of the encephalopathy can be measured by EEG
- Is the “gold standard” to diagnose electrographic neonatal seizures (ENS)

EEG measures the difference in voltage between 2 points, which changes over time...

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>Delta</td>
<td>&lt; 4 Hz</td>
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<tr>
<td>Theta</td>
<td>4-7 Hz</td>
</tr>
<tr>
<td>Alpha</td>
<td>8-12 Hz</td>
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<tr>
<td>Beta</td>
<td>&gt; 12 Hz</td>
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EEG Voltage Fields: Phase Reversals

Montage: An Array or Collection of Electrode Couples

Conventional Versus Limited Channel EEG monitoring

10-20 system: Full array
10-20 system: modified for neonates
aEEG (F3→F4)

(Olejniczak, Journal of Clinical Neurophysiology, 2006)

Drs. Robert Clancy & Eilon Shany: Jan. 18, 2008
Definitions of Behavioral States

- **Biobehavioral States:**
  - Normal
    - Awake = Eyes open
    - Asleep = Eyes closed
      - Active = REM, facial movements, irregular breathing pattern
      - Quiet = relatively few body movements; regular breathing pattern
  - Abnormal
    - Lethargy/Coma = Abnormal, Eyes closed
    - Undetermined = Eyes fused or baby paralyzed

Basic Ingredients of Neonatal EEG

- Continuity vs discontinuity
- Spontaneous or reactive lability
- Amplitude or voltage
- Specific background *components*

Measurements of Discontinuity

burst duration #1
interburst duration #1
interburst duration #2
burst duration #2
burst duration #3
interburst duration #3
Developmental Progression of Continuity
Overview of Concepts

<table>
<thead>
<tr>
<th>CONCEPTIONAL AGE (WKS)</th>
<th>BEHAVIORAL STATE</th>
<th>Active Sleep &amp; Awake</th>
<th>Quiet Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 29</td>
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<td>46</td>
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**Normal Discontinuity**

- Primitive/primordial discontinuity
  - long IBIs; unreactive
- Tracé discontinu (CA ~ 30-35 weeks)
- Tracé alternant (CA ~ 36-44 weeks)

*With maturation....*

Discontinuity relates to quiet sleep
Continuity dominates active sleep and wakefulness

**Interburst Intervals (IBIs)**

Shortens with Conceptional Age
Tracé Alternant in Quiet Sleep
CA=Term

Forms of Abnormal Discontinuity

- Excessively prolonged IBI values for CA
- Excessive proportion of tracing is represented by discontinuous background
- Excessively discontinuous in quiet sleep (IBIs abnormally long or low voltage in QS but continuous EEG during awake / active sleep)
- Burst Suppression

Burst suppression
CA = 42 weeks - 2° to HIE
Burst Suppression
CA = 38 weeks with multiple cong. anomalies & arthrogryposis

Reactivity and Lability

- Reactivity: EEG changes from “external” stimuli
- Lability: spontaneous changes from “internal” arousal mechanisms
  - Requires functional connection between thalamus and cortex

Abnormal Background Voltage

- “Flat” or “Isoelectric”: < 2 µV
- “Extremely low voltage”: < 5 to 10 µV
- “Asymmetric voltage”
  - left vs right amplitude ratio > 2:1
Extremely Low Voltage Tracing

The Normal “Ingredients” of the EEG
Specifically Named Background Patterns and Rhythms

- Rhythmic occipital/temporal “theta delta” activity
- Rhythmic occipital/temporal “Delta Brushes” activity
- Anterior Dysrhythmia
- Encoches Frontales

With Maturation

From Slow Delta and Theta to faster “Delta Brushes”

Slow waves with superimposed fast activity
(“Delta Theta”) CA=27W
Monorhythmic Occipital Delta Activity
CA = 28 weeks

Slow waves with superimposed fast activity
(Delta Brushes) CA = 30W

Encoches Frontales
(Frontal Sharp Waves)
The Term Infant
EEG seizures are **focal**
(compared to the “global” nature of EEG background)

<table>
<thead>
<tr>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Patient 3</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="EEG waveform" /></td>
<td><img src="image2.png" alt="EEG waveform" /></td>
<td><img src="image3.png" alt="EEG waveform" /></td>
</tr>
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**What’s Next?**

- A conventional EEG *workshop* with actual EEG recordings from:
  - Normal and abnormal premature infants, presented by **Eilon Shany**
  - Normal and abnormal term infants, presented by **Robert Clancy**
EEG of Premature Infants
Case 1

- Preterm 25 weeks Gestation, AGA
- Mild Respiratory Distress Syndrome
- Normal Head US until discharge
- First EEG at the age of two weeks (27 CA)
  - Note high amplitude slow waves
  - Superimposed Theta waves
  - Long interburst interval
  - Some relation between EEG and sleep states

Case 1

EEG of Premature Infants
Case 2

- Same infant at his 7th week (32CA)
  - Note lower amplitude slow waves
  - Superimposed fast rhythms (Delta Brushes)
  - Discontinuous tracing at quiet sleep
  - Somewhat longer than expected interburst interval
Abnormal Premature EEG
Case 3

- Preterm infant 29 weeks gestation, AGA
- Respiratory Distress syndrome
  - Weaned at one week of age from respirator
- Apnea of prematurity
- First EEG at the age of 10 days
  - Normal EEG architecture
    - Slow waves with superimposed fast rhythms
  - Abnormal “graphic elements”
    - Positive Rolandic sharp waves
- Brain US scan
  - Extensive frontoparietal echodensities with later cyst formation
### Abnormal premature EEG

**Case 4**

- Preterm 24-25 weeker, AGA
- Chorioamnionitis,
- No prenatal steroids
- Respiratory distress syndrome
- Severe pulmonary Hypertension
- Normal Head US throughout
- Multiple intestinal Perforations and Ischemia
- Deceased at the age of one month

### Abnormal premature EEG

- **aEEG**
  - Discontinuous, seizures
- **EEG at 10 days**
  - Discontinuous
  - Long interburst intervals
  - High Amp slow waves
  - Superimposed theta
  - Short seizure episodes

3 hours aEEG