aEEG & the Olympic Brainz Monitor
Florida FN3 Meeting
Nemours Children’s Hospital
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Objectives

Upon completion of this program, the clinician will be able to:

• Describe aEEG trace nomenclature and qualifications as they pertain to term babies and premature babies at various gestational ages
• Describe aEEG trending components including filtering, compression, rectification
• Assess aEEG trace patterns and apply trace qualifications for areas of suspicion/suspected seizures
• Describe aEEG electrode options, including preparation and placement
• Hands-on practice with aEEG electrodes
• Q & A
What is aEEG?

• aEEG is:
  - 1, 2, or 3 channel bedside brain monitor
  - Basic neurologic function trending tool
  - Long-term monitoring capability
  - Used to measure global electro-cortical activity or specific site brain activity
  - Developed by Neonatologists, for Neonatologists
  - Complimentary tool to *quickly* obtain information regarding the baby’s neurological status
Monitoring Tools in the NICU
What Do We Want to Know When We Monitor the Brain with aEEG?

• **What is the neurological status of the patient?**
  - Is there cerebral injury?
  - What is the severity of the injury?
  - What changes are occurring over time?
    • Is there improvement or worsening of the neurological status
  - What is the impact of NICU treatments to the patient’s brain function?

• **Is the patient having seizures?**
  - What is causing the seizures?
  - Are the seizures occurring more frequently, or for longer/shorter duration?
  - Are the seizures responding to medical therapy?
    • Is there electromechanical disassociation after medication?
### Who Should Be Monitored? | Clinical Applications

<table>
<thead>
<tr>
<th>Infants that have experienced a sentinel event during delivery and are at risk for hypoxic ischemic encephalopathy (HIE):</th>
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</thead>
<tbody>
<tr>
<td>- Low Apgar</td>
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<td>- Low pH</td>
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<tr>
<td>- Required resuscitation or artificial ventilation at birth</td>
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<tr>
<td>- Poor tone/poor reflexes</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Infants receiving hypothermia treatment for HIE</th>
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</thead>
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<tr>
<th>Infants with definite or questionable seizures (clinical or subclinical):</th>
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<tr>
<th>Infants with unexplained neurological symptoms (i.e. severe apnea)</th>
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<tr>
<th>Infants who are at higher risk for cerebral complications due to circulatory instability</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Sepsis</td>
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<tr>
<td>- Hypoxia</td>
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<tr>
<td>- Persistent pulmonary hypertension</td>
</tr>
<tr>
<td>- Meconium aspiration</td>
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<tr>
<td>- Cardiac malformations</td>
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<tr>
<td>- Diaphragmatic hernia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional clinical applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Muscle relaxed/neuromuscular blockade</td>
</tr>
<tr>
<td>- Grade 3 or 4 IVH</td>
</tr>
<tr>
<td>- ELBW infants</td>
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<tr>
<td>- Inborn errors of metabolism (e.g. urea cycle disorders, hypoglycemia, hypocalcemia)</td>
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<td>- Neonatal abstinence syndrome (e.g. alcohol/opiate withdrawal)</td>
</tr>
<tr>
<td>- Post surgical</td>
</tr>
<tr>
<td>- Post cardiac arrest</td>
</tr>
<tr>
<td>- Infants requiring ECMO or surgery for CHD</td>
</tr>
</tbody>
</table>


*NeoReviews* Vol 7 No. 2 February 2006
Hellstrom-Westas, Rosen, deVries, Greisen
Breakdown - How Does aEEG Work?

- **aEEG** ("a"=amplitude integrated / EEG = electroencephalography):
  - One, two, or three channels of EEG that go through a number of modifications:
    - special filtering
    - rectification
    - compression
    - very slow, trend display
  - aEEG is a process of taking a raw EEG, modifying it, and producing a trending pattern that allows clinicians to measure and view the microvoltage of the brain over time
Two electrodes are needed to create a single channel.

EEG waves reflect electrical voltage differences between these two electrodes sites:
- Measured in microvolts (µV)
aEEG Channels & the 10-20 System

- The Olympic Brainz Monitor may be used to monitor and record aEEG patterns through either:
  
  - Cross-Cerebral (default mode)
    - 3 electrodes - 2 active & 1 hydrogel ground
    - 1 aEEG channel (P3/P4)
    - 1 EEG channel (P3/P4)
  
  - Bilateral
    - 5 electrodes – 4 active & 1 hydrogel ground
    - 3 aEEG channels (C3/P3, C4/P4, P3/P4)
    - 3 EEG channels (C3/P3, C4/P4, P3/P4)
Filtering

- The EEG signal is filtered 2–15 Hz
- Specially shaped filter
- Reduces muscle and other artifacts
Rectification
Compression

Log – 11-100 µVolts

Linear – 0 - 10 µVolts

No Session Data
Very Slow, Trend Display

OLYMPIC BRAINZ MONITOR

3 hours

No Session Data
Background Information - Margins
Background Information – Sleep Wake Cycling (SWC)

- SWC characterized by:
  - Smooth sinusoidal variations, mostly in the lower margin
  - Broader bandwidth represents discontinuous background activity during quiet sleep
  - More narrow bandwidth corresponds to more continuous activity during wakefulness and active sleep
  - Quiet Sleep Cycle duration ≥ 20 minutes
    - Total SWC ~60-90 minutes
## aEEG Classification Framework

Feb 2006 – NeoReviews – Hellstrom Westas

<table>
<thead>
<tr>
<th>Pattern Definition (Hellstrom-Westas &amp; Toet)</th>
<th>Lower Margin (in μV)</th>
<th>Upper Margin (in μV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Normal Voltage</td>
<td>&gt; 5</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Discontinuous Normal Voltage</td>
<td>&lt;5</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Burst Suppression</td>
<td>&lt;5</td>
<td>&gt;10 due to high voltage bursts</td>
</tr>
<tr>
<td>Continuous Low Voltage</td>
<td>&lt;5</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Isoelectric/Flat</td>
<td>&lt; 5</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>
aEEG and TERM Babies
Continuous Normal Voltage

- Sleep/Wake Cycling
- Upper Margin > 10 µVolts
- Lower Margin > 5 µVolts
- Limited Bandwidth Variability (between upper and lower margin)
  - ~5-10 µVolts
Discontinuous Normal Voltage

- No Sleep/Wake
- Upper Margin > 10 µVolts
- Lower Margin < 5 µVolts
- Increased Bandwidth Variability
  - ~30 – 40 µVolts
Discontinuous Normal Voltage
Burst Suppression

- No Sleep Wake Cycling
- Upper margin >10μV (due to high voltage bursts)
- Lower margin <5μV
- Limited variability of lower margin
Continuous Low Voltage

- No Sleep/Wake Cycling
- Upper margin <10uV
- Lower margin <5uV
Isoelectric or Flat

- No Sleep/Wake
- Upper Margin < 5 µVolts
- Greatly reduced bandwidth variability
  - ~1 µVolt
Seizure EEG
Status Epilepticus
Continuous Normal Voltage

Discontinuous Normal Voltage

Burst Suppression

Continuous Low Voltage

Isoelectric

Seizures
Impedance and Artifact

• Impedance
  - A measure of the quality of electrode contact
  - Anything that gets between the sensor (hydrogel or low impedance needles) and “impedes” or interferes with the devices ability to read the brain signal (hair, dry skin, vernix)

• Artifact
  - Any electrical activity other than the brain’s electrical activity (monitors, IV pumps, ventilators, etc.)
  - Live EEG signal is used as a point of reference to confirm suspected brain activity OR to distinguish artifact from the real signal
ECG Artifact

Cross aEEG

Cross EEG (μV) @ 15 mm/sec

EEG (μV)

aEEG (μV)
aEEG and Premature Babies
Pre-Term Infants

<table>
<thead>
<tr>
<th>Gestational or Postconceptual Age (wk)</th>
<th>Dominating Background Pattern</th>
<th>SWC</th>
<th>Minimum Amplitude (mcV)</th>
<th>Maximum Amplitude (mcV)</th>
<th>Burst/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 through 25</td>
<td>DC</td>
<td>(+)</td>
<td>2 to 5</td>
<td>25 to 50 (to 100)</td>
<td>&gt;100</td>
</tr>
<tr>
<td>26 through 27</td>
<td>DC</td>
<td>(+)</td>
<td>2 to 5</td>
<td>25 to 50 (to 100)</td>
<td>&gt;100</td>
</tr>
<tr>
<td>28 through 29</td>
<td>DC/(C)</td>
<td>(+)/+</td>
<td>2 to 5</td>
<td>25 to 30</td>
<td>&gt;100</td>
</tr>
<tr>
<td>30 through 31</td>
<td>C/(DC)</td>
<td>+</td>
<td>2 to 6</td>
<td>20 to 30</td>
<td>&gt;100</td>
</tr>
<tr>
<td>32 through 33</td>
<td>C/DC in QS</td>
<td>+</td>
<td>2 to 6</td>
<td>20 to 30</td>
<td>&gt;100</td>
</tr>
<tr>
<td>34 through 35</td>
<td>C/DC in QS</td>
<td>+</td>
<td>3 to 7</td>
<td>15 to 25</td>
<td>&gt;100</td>
</tr>
<tr>
<td>36 through 37</td>
<td>C/DC in QS</td>
<td>+</td>
<td>4 to 8</td>
<td>17 to 35</td>
<td>&gt;100</td>
</tr>
<tr>
<td>38+</td>
<td>C/DC in QS</td>
<td>+</td>
<td>7 to 8</td>
<td>15 to 25</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

SWC: (+) = imminent/immature; SWC: + = developed; SWC: QS = quiet/deep sleep; DC = discontinuous background pattern; (C) = continuous
Normal aEEG’s at Various Gestational Ages

Thornberg & Thiringer 1990, Kuhle et al 1999)
Olympic Brainz Monitor
Electrode Placement

- 3 Electrodes
  - 2 Active
    • Hydrogel
    • Low impedance needles
  - 1 Reference/Ground
    • Hydrogel

- Lead Placement:
  - P3/P4 placement
  - Reference Ground
    • back or chest
Olympic Brainz Monitor

Electrode Placement

- 5 Electrodes
  - 4 Active
    - Hydrogel
    - Low impedance needles
  - 1 Reference/Ground
    - Hydrogel

- Lead Placement:
  - C3/P3 and C4/P4 placement
  - Reference Ground
    - back or chest
Olympic Brainz Monitor – Patient Preparation

• The following steps describe the preparation and application of the 5 electrode configuration

• Omit the application of the anterior (most forward pair) of electrodes when the 3 electrode configuration is employed
• Sensors
  – Electrode Set
    • Hydrogel electrodes
    • Low impedance needle electrodes
    • Other – 1.5 mm compatible electrodes

• Positioning Aid
• Skin Marker
• Skin Prep
  – Hydrogel electrodes
    • NuPrep™, water, gauze, cotton swab, wrap hat (optional)
  – Low impedance needle electrodes
    • Antiseptic prep
    • Tape or other securing adhesive
• Comb – if excessive hair is present
Positioning Aid – Ear Tragus
Positioning Aid – Sagital Suture
Positioning Aid

Ear Tragus

Sagital Suture
Marking Electrode Sites
Part Hair and Prepare Skin
Apply Hydrogel Electrodes
Channels

Cross Cerebral or Bi-Parietal
1 Channel

Bi-Lateral – 2 Channels

Bi-Lateral and Cross Cerebral
3 Channels
• Hydrogel Electrodes
• Low Impedance Needle Electrodes
• Other
Which Type of Electrode is Appropriate?

- Considerations in Electrode Selection:
  - Anticipated length of monitoring
    - Short vs Long-Term
  - State of the baby
    - Acuity
    - Tolerance of handling
  - Physiologic considerations
    - Hair
    - Gestational age
    - Condition/fragility of skin
  - Special considerations:
    - IV’s
    - Scalp injuries
    - CPAP
    - Phototherapy
    - NIRS
Skin Prep Suggestions – Hydrogel Electrodes

• Allow the hydrogel electrodes to warm by placing on the radiant warmer bed while prepping the skin
• It is recommended you prep and place one electrode at a time when possible
• Always apply the skin prep gel directly to the skin
• Never apply skin prep gel directly to an electrode – it can increase impedance
• Run a finger around the edges of the electrode for 20-30 seconds after placement to warm the electrode to the skin and ensure a secure seal
• Optional - Use a wrap hat as an additional measure to secure the electrodes
Low Impedance Needle – Preparation Supplies
Low Impedance Needle Electrodes - Safety

- Note – the blue plastic housing of the low impedance needle electrode is also meant to be utilized to minimize the risk of needle stick when removing from the patient
  - To advance the low impedance needle from the hub:
    - Hold the blue plastic housing between your thumb and forefinger and press slightly.
    - Advance the lead wire from the bottom until the low impedance needle and black hub are exposed
    - Grasp the black hub and slide the blue plastic housing to the distal end of the lead wire
  - To remove the low impedance needle from the baby:
    - Hold the blue plastic housing and gently pull the lead wire back until the needle has completely retracted
    - Discard in sharps container
Insert Subdermally
Olympic Brainz Monitor – Reference / Ground Hydrogel Electrode

- Select a site with minimal hair
  - Shoulder
  - Neck
  - Behind the ear

- Repeat previous steps to clean reference/ground electrode site

- Place electrode
Secure Electrodes
Connect Electrodes to DAB

Nose

Left Ear

Right Ear

3 Electrode/Cross-Channel Configuration

5 Electrode/Bi-Lateral Configuration
Check Signal Quality

1. Click on the 'Signal' button.

2. Observe the signal quality plots.

3. Check for any session data.
Troubleshooting – High Impedance Alert Hydrogel Electrodes

- Check the hydrogel sensor from the skin to the D.A.B.
  - Make sure all electrodes are properly connected to the D.A.B.
  - Make sure the D.A.B. is properly connected to the Olympic Brainz Monitor
  - If an electrode is lifting, attempt to rehydrate and reapply
    - To re-hydrate:
      - Slightly lift or remove electrode
      - Wet electrode surface with a drop of water
Troubleshooting – High Impedance Alert
Low Impedance Needle Electrodes

• Check the low impedance needle sensor from the skin to the D.A.B.
  • Make sure all electrodes are properly connected to the D.A.B.
  – Make sure the D.A.B. is properly connected to the Olympic Brainz Monitor
  – If an electrode is dislodged, obtain a new low impedance electrode, clean new site, insert, and secure with tape or other adhesive
aEEG Reference Literature

Reference:
Thank you for joining our eSeminar!

Please visit the Neonatal Care Academy for additional learning opportunities: www.neonatalcareacademy.com