Glossary of terms

cEEG       conventional electroencephalogram
Video cEEG  conventional electroencephalogram with video
aEEG       amplitude integrated electroencephalogram

Background for aEEG and cEEG

Neonatal brain monitoring by amplitude integrated EEG (aEEG) or long term conventional electroencephalogram (cEEG) is important to evaluate and grade brain dysfunction from multiple causes, such as ischemia, infections, metabolic disorders or structural disorders, to detect seizures, and to predict outcomes after hypoxic insult or other brain injury in premature and term infants.

There are two types of systems used to monitor infants: standard full lead EEG and limited channel aEEG. Both techniques have advantages and disadvantages. cEEG is the gold standard tool to continuously assess neurologic function, and is more sensitive and specific for detecting a seizure or background abnormality. Its disadvantage is the expertise required for application and interpretation. The main benefit of aEEG is that it can be applied and interpreted after a limited training period. Because of its lower sensitivity and specificity in detecting seizures, aEEG should supplement, but not replace cEEG. Newer technology allows machines to record both cEEG and aEEG with simultaneous time locked video. Video-aEEG and cEEG helps determine if there is a correlation between brain activity and the events in question.

Bedside monitoring via aEEG can be one channel or two channels. Both the one and two channel monitoring can provide information on background activity, maturation, classification, and effects of medications. Two channels allow for detection of asymmetry in background activity and early recognition of seizures in infants with unilateral or predominantly unilateral brain lesion.

This document is divided into two sections. The first section provides information and is the guidelines for aEEG monitoring. Following this, are the guidelines for cEEG monitoring. There is overlap with the two documents in the indications for monitoring section. This is because most if not all patients who will require cEEG will remain on aEEG. The advantage of having both aEEG and cEEG be displayed is that it allows the bedside neonatal team to review and interpret the aEEG while the neurologist is able to interpret the cEEG.

I. Indications for aEEG Monitoring

Monitoring via aEEG will be initiated for every full term or premature infant in which there is a concern for seizures, encephalopathy, or for routine monitoring in premature infants.

NB. Most all of these patients, except those at risk for HIE, or who receive medical paralysis, or who have an initial aEEG placed because of prematurity will also have a cEEG placed.
1. Differential diagnosis of abnormal paroxysmal events (evaluation of suspected seizures)
   - Focal clonic or tonic movements
   - Intermittent forced, conjugate horizontal gaze deviation
   - Myoclonus
   - Generalized tonic posturing
   - Repetitive stereotyped movements (oral-buccal-lingual, swimming, boxing and bicycling)

2. Detection of electrographic seizures in selected high-risk population
   - Neonatal encephalopathy due to any cause (see #3)
   - Medical paralysis
   - Frequent or profound apnea persisting near term (≥ 34 weeks)
   - Infants with newly diagnosed grade III IVH or periventricular hemorrhagic infarct
   - Severe persistent pulmonary hypertension (PPHN)
   - Extracorporeal Membrane Oxygenation (ECMO) prior to cannula insertion
   - During or immediately following major surgery
   - CNS infection
   - CNS trauma
   - Perinatal Stroke (suspected or confirmed)
   - Sinovenous Thrombosis (suspected or confirmed)
   - Critically ill infants in whom there is a concern for seizures (e.g., sepsis)
   - Genetic/syndromic disease involving the CNS

3. Evaluation of neonatal encephalopathy (neonates with exam findings listed below)
   - Hyperalert state (as a stage in the progression of encephalopathy)
   - Lethargy
   - Stupor or coma
   - Hypotonia
   - Abnormal reflexes (including oculomotor or papillary abnormalities)
   - Absent or weak suck

4. At risk for HIE
   - Prolonged resuscitation at birth (i.e. chest compressions and/or intubation or mask ventilation at 10 minutes)
   - Low Apgar scores (< 5 at 10 minutes)
   - Severe acidosis (cord pH or any arterial pH 7.00 within 60 minutes of birth or code event)
   - Abnormal Base Excess (< 12mmol/L in cord gas or blood gas within 60 minutes of birth or code event)
   - Significant resuscitation after a code event

5. Premature Infants
   - Routinely for every baby < 28 weeks gestation
   Adapted from Shellhaas R et. al, Journal of Clinical Neurophysiology Volume 28, Number 6, 2011

II. Identification of Infants and Initiation of aEEG
   - The ICN/NICN team will identify infants for aEEG monitoring
   - Priority for aEEG monitoring will include infants at risk for seizures and brain injury.
• For premature infants < 28 weeks gestation, begin monitoring within the 1st few hours of life or as soon as possible
• The ICN MD/NNP will place the order to begin monitoring and notify the NICN neurology service fellow or attending physician:
  o 24 hours a day, 7 days a week for evaluation of suspected seizures
  o Daytime for monitoring of aEEG background
• Equipment set up and lead placement is done by the NICN nurse, fellow, NNP, or attending physician.

aEEG Monitors
  o Olympic ® 1 channel, used primarily for research monitoring
  o Moberg® 2 channel, used for routine monitoring
  o Viasys® 2 channel, used for all HIE patients, and patients at risk for seizures. The Viasys® has the ability to provide video cEEG as well as aEEG. The Viasys® can be connected to the network and the cEEG can be reviewed remotely by the neurophysiologist.

aEEG Leads
  o Spider® disk electrodes are routinely used
  o Gel electrodes may be used on the premature infant with mature skin. Consider gel electrodes for routine short term monitoring (6-8 hours) in the premature infant.

Olympic ® is 1 channel and uses 3 leads
  Ground is placed 2.5cm anterior to vertex
  P3 is placed 5cm posterior to vertex and 3.75cm to left
  P4 is placed 5cm posterior to vertex and 3.75 cm to right
  P3-P4 has a distance of 7.5cm between them

Measurement for lead application is important to capture accurate data. Use a measuring tape when applying leads.
The goal is to create a triangle between Ground and P3 and P4.

See Nursing Policy and Procedure Manual for additional information
The Moberg® and Viasys® use 2 channels and 4 leads
- Reference is placed in the center of the head near the forehead
- Ground is placed near the reference (or anywhere) but not touching the reference
- C3 is placed midway between the vertex and top of left ear
- C4 is placed midway between the vertex and top of right ear

Measurement for lead application is important to capture accurate data. Use a measuring tape when applying leads. The goal is to create a triangle between Reference and C3 and P4.
For additional information see the Nursing Policy and Procedure Manual

III. Interpretation and Reporting aEEG
- If the upper and lower margins are abnormally elevated at the onset of the recording this may indicate a seizure or status epilepticus; neurology should be notified immediately, and the EEG tech called for placement of a cEEG. The aEEG should be evaluated every 20 minutes until the cEEG has been placed and can be evaluated by the neurologist/neurophysiologist.
  ○ NB. This elevation may be interpreted as artifact or technical difficulties – no more than 30 minutes should be spent in addressing technical problems as this may truly represent seizure or status epilepticus.
- In the setting of suspected seizures or profound encephalopathy, the neonatal fellow or NNP and attending should review the aEEG at:
  ○ Onset of placement
  ○ Every 20 minutes for the 1st hour of recording
- If there is no immediate concern for seizures, the tracing should be reviewed at a minimum of every 3 hours by the ICN bedside medical team.

aEEG Evaluation Includes:
- Technique and Quality
- Sleep Wake Cycling (yes/no or cannot interpret)
- Background Pattern Classified as:
  - Normal
  - Discontinuous normal voltage
  - Burst-suppression
  - Continuous low voltage
• Flat tracing
• Cannot interpret
• Seizures (yes/no or cannot interpret)
• NICN nurses will monitor and document every 1-2 hours and PRN, background patterns including upper and lower margins, sleep-wake cycling, and events that indicate possible seizures.
• aEEG monitoring will be routinely reviewed every 24 hours by a NICN attending neonatologist and the NICN neurology service. Results of this interpretation will be communicated to the ICN attending to be included in the patient’s daily progress note.

In the event of concerning findings, a recommendation may be made for a full cEEG, at which time; a formal NICN neurology consult will be completed.

IV. Duration of aEEG Monitoring
Monitoring via aEEG should continue for a minimum of 24 hours to evaluate background, detection of seizures, and sleep wake cycling. The exception is the routine monitoring for premature infants.

Suggested recommendations for duration of aEEG monitoring
• Monitoring should be continued until the patient is stable from major cerebral insult (discuss with NICN service) or until:
  o Background recording has been stable for 24 hours AND
  o No seizures for 24 hours
• Monitoring for hypothermia patients should continue throughout cooling, rewarming and until the patient is prepped for MRI (unless MRI is delayed > 24 hours after rewarming). Following MRI, aEEG monitoring may resume if indicated.
• For routine monitoring of premature infants < 28 weeks gestation
  o Monitor for 72 hours (beginning in the 1st first hours after birth if possible). Longer monitoring may be indicated for clinical concerns or abnormal HUS or MRI.
  o Continue weekly 6-8 hour recordings until 32 weeks corrected age

V. Clinical Decision-Making on aEEG
• The aEEG should be interpreted with caution and only within the context of the history, physical examination and ancillary tests.
• The aEEG should never replace conventional video EEG (unless cEEG is technically impossible)
• The background recording can be used along with clinical, laboratory and radiological information when evaluating the prognosis of an encephalopathic infant
• The aEEG should never be used for evaluation of brain death
• Suspected electrographic seizures detected by aEEG must be evaluated as soon as possible with a conventional video EEG
• Infants with unexplained changes in vital signs or subtle signs of suspected seizures should have conventional video EEG in addition to EEG
• Definite electrographic seizures detected by aEEG should be treated according to standard NICN seizure guidelines
• The NICN neurology service should be consulted 24 hours a day, 7 days a week as clinically indicated and on every monitored baby.

Referenced from:
The Atlas of Amplitude Integrated EEG in the Newborn, by Hellstrom-Westas, DeVrie and Rosen

Approved by the NICN committee 4/12