Kidz Medical Services
Neonatal Polysomnogram

**Purpose:**
To provide the clinicians of Kidz Medical Services with guidelines for the consistent utilization of neonatal polysomnogram (PSG).

**Guideline:**

I. General Information:
   A. Instability of the breathing pattern is an inherent characteristic of the normal healthy infant during sleep.
   B. Occurrence of apneas of short duration is a physiological phenomenon that declines with advancing postnatal age.
   C. We must be aware of the triggering or predisposing factors that can suddenly turn a physiological phenomenon to a pathological one.
   D. PSG is the gold standard for the diagnosis of sleep-disordered breathing in infants.
   E. PSG should be performed as soon as the diagnosis of sleep-disordered-breathing in infants is suspected.
   F. Early diagnosis and treatment allows the protection of infants against poor growth, cardiorespiratory failure, or even sudden death. Furthermore, undiagnosed sleep-disordered-breathing disturbs sleep architecture and therefore the neurocognitive development of the infants.

II. Definition of polysomnogram (PSG):
   A. PSG is a comprehensive recording of the biophysiological changes that occur during sleep.
   B. PSG monitors many body functions including brain (EEG), eye movements (EOG), muscle activity submental and limb movements (EMG), nasal airflow, breathing function or respiratory effort during sleep, heart rhythm (ECG), strider-snoring and oxygen saturation.
   C. PSG is the most adequate electrophysiologic test to identify apnea in preterm and at-term newborns, and should be performed in all infants with risk factors.
   D. PSG is the preferred technique to identify different sleep states.

III. Sleep:
   A. Sleep is a life function as vital as breathing or feeding. In the neonatal period, sleep is the main behavioral state, especially in the preterm newborn.
   B. Sleep is defined as a physiologic state of relative unconsciousness and inaction of the voluntary muscles and by the periodic recurrent need to achieve this state.
   C. Sleep is not a passive phenomenon, but the result of active mechanisms between the brainstem and the forebrain.
   D. Recordings of EEG, EOG, EMG, and respiration are essential to differentiate sleep states.
   E. Diligent documentation of behavior and video monitoring as well as caregiver interventions are also essential to assist in accurately staging.
   F. In the newborn and the young infant younger than 6 months of age, 3 specific sleep states have been described:

   1. Active sleep (AS), which corresponds to REM sleep in adults, is the main sleep state and is characterized by EEG low voltage mixed frequency the presence of REM rapid
eye movement, low muscle tone, irregular heart and respiratory rate. Paradoxic
respiratory efforts, intermittent body movements, jerks, grimaces and twitches.
2. Quiet sleep (QS), corresponding to the non-REM sleep in adults, is marked by the
EEG that evolves from Trace’ discontinue to ‘Trace’ alternant to mature NREM,
absence of eye movements, sustained EMG tone, regular respiration and heart rate, and
few body movements.
3. Indeterminate sleep (IS) is a state in which the EEG is disorganized. The sleep
characteristics are not clearly classifiable as QS or AS. The period of IS at the
beginning of sleep and between QS and AS is called transitional sleep.
Wake in infants is not distinguished by EEG, EOG, and/or EMG patterns. Observation
such as eyes open, crying, caregiver intervention or movements are necessary to define
wake.

IV. Apnea:
A. Definitions of apnea: (National Institute of Health Consensus Development Conference
Statement September 29-October 1, 1986).
1. Apnea- Cessation of respiratory air flow. The respiratory pause may be central
or diaphragmatic (ie., no respiratory effort) obstructive (usually due to upper airway
obstruction), or mixed, central apnea can be normal at all ages.
2. Pathologic apnea- A respiratory pause is abnormal if it is prolonged (20seconds) or
associated with cyanosis, abrupt, marked pallor or hypotonia, or bradycardia.
3. Periodic breathing- A breathing pattern in which there are three or more respiratory
pauses of greater than 3 seconds duration with less than 20 seconds of respiration
between pauses. Periodic breathing can be a normal event.
4. Apnea of prematurity (AOP)- Periodic breathing with pathologic apnea in a
premature infant. Apnea of prematurity usually ceases by 37 weeks gestation, but
occasionally persists to several weeks past term.
5. Asymptomatic premature infants- Preterm infants who either never had AOP or
whose AOP has resolved.
6. Symptomatic premature infants- Preterm infant who continue to have pathologic
apnea at the time when they otherwise would be ready for discharge.
7. Apnea of infancy (AOI)- An unexplained episode of cessation of breathing for 20
seconds or longer, or shorter respiratory pause associated with bradycardia, cyanosis,
pallor, and or market hypotonia. The terminology of “apnea of infancy” generally refers
to infants who are greater than 37 weeks gestational age at onset of pathologic apnea.
AOI should be reserved for those infants for whom no specific cause of ALTE can be
identified. In other words, these are infants whose ALTE was idiopathic and believed to
be related to apnea.
8. Apparent life-threatening event (ALTE)- An episode that is frightening to the
observer and that is characterized by some combination of apnea (central or
occasionally obstructive), color change (usually cyanotic or pallid but occasionally
erythematous or plethoric), marked change in muscle tone ( usually marked limness),
choking or gagging. In some cases the observer fears that the infant has died.
9. Sudden Infant Death Syndrome (SIDS)- The sudden death of any infant or young
child, which is unexplained by history and in which a thorough postmortem
examination fails to demonstrate an adequate explanation of the cause of death.

B. Apnea is classified as central, obstructive, and mixed (The AASM Manual for the Scoring
of Sleep and Associated Events, 2007)
1. Obstructive apnea if meets all of the following criteria:
a) Absence of ≥ 2 missed breaths.
b) ≥ 90% fall in amplitude of the airflow for ≥ 90% of the entire respiratory event.
c) The event is associated with continued or increased inspiratory effort throughout the entire period of decreased airflow.
d) The duration of the apnea is measured from the end of last normal breath to the beginning of the first breath that achieves the pre-event baseline inspiratory excursion.

2. Central apnea: If it is associated with absent inspiratory effort throughout the entire duration of the event and 1 of the following is met:
   a) The event lasts 20 seconds or longer.
   b) The event lasts at least 2 missed breaths (or the duration of 2 breaths as determined by baseline breathing pattern) and is associated with an arousal, and awakening or a ≥ 3% desaturation.

Notes:
1) An apnea during sleep in an infant or child does not need to cause an arousal, awakening or arterial oxygen desaturations to be scored.
2) A central apnea which last at least 2 missed breaths (or the duration of 2 breaths as determine by baseline breathing pattern), but is less than 20 seconds and immediately follows a snore, sigh, respiratory event or arousal is not scored unless it causes either an arousal, an awakening or a ≥ 3% desaturation.

3. Mixed Apnea:
   a) Same us OA, but with an initial central apnea component.

V. Research studies:
   A. Apnea of prematurity (AOP):
      1. Prevalence is inversely related with gestational age and birth weight.
         a) 25-50% in infants < 1500 gm.
         b) 90% in infants < 1000 gm.
         c) Most common and frequently recurring problem in very low birth weight infants.
      2. Three types of apnea: Central 58%; Mixed 35.5%; Obstructive 6.5%. (Upton et al, 1992).
      3. A large percentage of apnea events were not detected by nursing staff (Southall et al 1983, Carroll et al. Not only identified less apnea, but also misclassified the type of apnea (Razi et al 1999).

   B. Preterm & SIDS:
      1. In 31 neonates dying suddenly and unexpectedly, 48% died in first 24 hours, 68% before 36 hours and 84% before 84 hours. (Dehan et al, 1992).
      2. Incidence of neonatal SDIS is estimated at 0.12–0.15 per 1000 live births (Polberger and Svenningsen, 1985; Rodriguez-Alarcon et al, 1994).

   C. Apnea of Prematurity & GER:
      1. GER is frequent during the first month of life.
      2. Laryngeal chemoreflex and respiratory Inhibition (Wennegren et al, 1993; Thach et al, 1992)
      3. Early studies suggested the relationship between GER and AOP (Spitzer et al 1984; Menon et al 1985)
4. Later studies showed no temporal relationship between GER and AOP (Peter et al 2002; Barrington et al 2002)
5. Risk for ALTE ?? (Paton et al, 1990)

D. Respiratory Physiology and Apnea of Prematurity (5th Annual Conference on Pediatric Sleep Medicine (David Gozal, MD)

1. Polysomnographic criteria
   a) Criteria for normal vs. abnormal being more fully define (CHIME study)
   b) SPO2 < 85% without brady ≥ 1/hr.
   c) > 5% TST SpO2 < 95%
   d) ≥ 2 mixed or OSA/hr with cardiac deceleration.
   e) Hypoxia with brady (< 70 bpm).

2. Prospective assessment of preemies:
   a) All asymptomatic preemies planed for discharge within 1 week who were born at <30 weeks GA or <1,250 g underwent NPSG either in sleep lab or in NICU.
   b) N=978 over 6 years
   c) Normal studies: 567 (58%)
   d) Mildly abnormal: 246 (25%) with mild (PB) periodic breathing or CA/OA with desats with and without brady but with spontaneous recovery- of these 138 were started on additional Tx (supplemental O2 or increase caffeine) + CR monitor.
   e) Abnormal: 165 (17%). Of these abnormal 165:
      (1) 39 had EEG seizure activity.
      (2) 126 had unsuspected severe apneic episodes associated with severe bradycardia or significant hypoxemia (< 85%).

E. Poblano, A. et al:
   1. 223 at risk babies had PSG.
   2. Nearly 25% of patients from a neonatal care unit presented apnea events.
   3. Infants with apnea showed lower values of age, weight, and cephalic perimeter at birth than infants without apnea, but did not show more neurologic risk factors.
   4. Central apnea events were more frequent in infants with preterm birth (birth weight <1,500 g), obstructive apnea events were observed in infants with hyperbilirubinemia and gastro-esophageal reflux, while mixed events were seen in infants with sepsis, and hyperbilirubinemia.
   5. Sleep PSG recordings detected that 36% of infants with apnea have no previous clinic suspicion of the problem.

VI. Indications for PSG:
   A. Most common indications:
      1. Apnea of Prematurity; with bradycardia and/or oxygen desaturations
      2. Sibling of SIDS victim
      3. Congenital Central Hypoventilation Syndrome
      4. Apparent Life Threatening Event (ALTE)
      5. Unexplained sleep related hypoxemia with or without bradycardia
      6. Mid-face congenital anomalies
      7. Seizures
      8. Decanulation of tracheostomy
   B. PSG indicated under certain circumstances:
      1. Gastroesophageal Reflux (GER)
2. Congenital hypotonia
3. Intracranial hemorrhage
4. Intracranial infection
5. Hypertonia
6. Infantile spasms

C. PSG potential indications:
   1. Intrauterine-drug exposure
   2. Bronchopulmonary dysplasia after ventilator weaning
   3. Abnormal feeding/swallowing
   4. Congenital malformation of the head, neck, and chest
   5. CNS abnormalities (e.g., hydrocephalus)
   6. State discordance and lack of circadian/ultradian organization

D. Consider PSG evaluation with the following high risk conditions:
   1. Craneofacial Syndromes
      a) Midfacial Hypoplasia
         (1) Apert syndrome
         (2) Crouzon Syndrome
         (3) Pfeiffer Syndrome
         (4) Treacher-Collins
      b) Macroglossia/glossoptosis:
         (1) Down syndrome
         (2) Beckwith-Wiedeman syndrome
         (3) Pierre Robin syndrome
   2. Neuromuscular disorders:
      a) Cerebral palsy
      b) Arnold-Chiari malformation
      c) Meningomyelocele
      d) Mobius syndrome
      e) Myasthenia gravis
      f) Duchenes muscular dystrophy
      g) Myotonic dystrophy
      h) Spinomuscular atrophy (SMA)
   3. Miscellaneous disorders:
      a) Prader-Willi Syndrome
      b) Hypothyroidism
      c) Mucopolysaccaridoses
      d) Sickle Cell disease
      e) Choanal stenosis
      f) Repaired cleft palate
      g) Laryngomalacia
      h) Airway papillomatosis
      i) Subglotic stenosis
   4. Other syndromes:
      a) Hallerman-Streiff syndrome
      b) Goldenhar syndrome
      c) Klippel syndrome
      d) Marfan syndrome
      e) Achondroplasia
VII. Procedure for PSG:
   A. Order a Mobile Cart Complete Polysomnogram
   B. Consult Dr Guzman with Sleep Institute of Florida. Office: Ph:(561) 588-1373 / 1292 Fax.
   C. Study takes about 10 hours (1 hour set up, 8 hour study, 1 hour clean up)

References:
- Staphen H. Sheldon, DO “ Atlas of Infant Polysomnogram”